Proceedings
of the
Thirtieth
Indian Science Congress

CALCUTTA, 1943

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NOTE

The Proceedings are issued in four parts as follows :

		Pages.
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Proceedings of the Thirtieth Indian Science Congress.

PART I -OFFICIAL MATTERS

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Members and Delegates at the 30th Indian Science Congress, Calcutta 1943.

PROCEEDINGS OF THE THIRTIETH INDIAN SCIENCE CONGRESS.

At the invitation of the University of Lucknow, the Executive Committee of the Indian Science Congress Association decided to hold the 30th Session of the Science Congress at Lucknow in January, 1943 under the auspices of the University of Lucknow and this information was placed before the General Committee at Baroda in January, 1942.

Appointments for the purpose at Lucknow were subsequently made by the Executive Committee and their list is as follows :—

List of Officers appointed at Lucknow.

PATRON :

HIS EXCELLENCY SIR MAURICE GARNIER HALLETT, K.C.S.I., C.I.E., I.C.S., GOVERNOR OF THE UNITED PROVINCES OF AGRA AND OUDH.

LOCAL SECRETARIES :

DR. A. C. CHATTERJI, D.Sc., Dr.Ing., Lecturer in Chemistry, University of Lucknow, Lucknow.

DR. A. N. SINGH, D.Sc., Reader in Mathematics, University of Lucknow, Lucknow.

LOCAL SECTIONAL SECRETARIES :

Mathematics and Statistics.—Dr. Rama Dhar Misra, M.A., Ph.D. (Edin.), Lecturer in Mathematics, University of Lucknow, Lucknow.

Physics.—S. B. L. Mathur, Esq., M.Sc., Lecturer in Physics, University of Lucknow, Lucknow.

Chemistry.—Dr. Soorya Narayan Shukla, M.Sc. (Luck.), Ph.D. (Lond.), A.I.C., Lecturer in Chemistry, University of Lucknow, Lucknow.

Geology and Geography.—Dr. R. V. Sitholey, Department of Botany, University of Lucknow, Lucknow.

Botany.—H. P. Chowdhury, Esq., M.Sc., D.I.C. (Lond.), Department of Botany, University of Lucknow, Lucknow.

Zoology and Entomology.—Prof. E. L. Jordan, M.Sc., Christian College, Lucknow.

Anthropology and Archæology.—Dr. Balkrishna Singhania, M.A., Ph.D., Research Scholar, Lucknow University, Lucknow.

Medical and Veterinary Sciences.—Dr. V. S. Mangalik, M.D., D.C.P., (Lond.), Reader in Pathology, K. G. Medical College, Lucknow.

Agricultural Sciences.—S. Sinha, Esq., M.Sc., Lecturer in Botany, University of Lucknow, Lucknow.

Physiology.—N. P. Benawri, Esq., M.B.B.S., Lecturer in Physiology, K. G. Medical College, Lucknow.

Psychology and Educational Science.—Kali Prasad, Esq., M.A., LL.B., Lecturer in Psychology and Philosophy, Department of Philosophy, University of Lucknow, Lucknow.

Engineering and Metallurgy.—N. P. Mathur, Esq., A.V.C., Civil Engineer, University of Lucknow, Lucknow.

Towards the end of November the University of Lucknow intimated their inability, owing to unforeseen difficulties, to make the necessary arrangements for the session being held in

the first week of January, 1943. They suggested postponement, which, in fact, would ultimately have led to the dropping of the Session altogether. The Executive Committee, however, felt that every effort should be made to maintain continuity of the Congress Sessions, particularly as all work for the scientific part of the Session had been completed. The Executive Committee approached the University of Calcutta and they very kindly extended an invitation even at late hour to hold the Session at Calcutta.

Owing to the change of venue of the Congress from Lucknow to Calcutta, the local officers appointed at Lucknow ceased to function and below is given the list of officers of the last Session at Calcutta.

His Excellency Sir John Arthur Herbert, G.C.I.E., Governor of Bengal and Chancellor of the University of Calcutta, sent a message of good wishes on the occasion of the opening of the Session.

1. OFFICERS OF THE THIRTIETH CONGRESS.

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D. N. WADIA, Esq., M.A., B.Sc., F.G.S., F.R.G.S., F.R.A.S.B., F.N.I.

PRESIDENTS OF SECTIONS:

Mathematics and Statistics.—Dr. S. C. Dhar, M.Sc., D.Sc. (Cal. & Edin.), F.R.S.E., F.N.I., Head of the Department of Mathematics, College of Science, University of Nagpur, Nagpur, C.P.

Physics.—Dr. H. J. Bhabha, Ph.D. (Cantab.), F.R.S., Special Reader in Cosmic Ray Physics, Indian Institute of Science, Bangalore.

Chemistry.—Prof. S. S. Joshi, M.Sc., D.Sc. (Lond.), University Professor and Head of the Department of Chemistry, Benares Hindu University, Benares.

Geology and Geography.—Dr. J. A. Dunn, D.Sc., D.I.C., F.G.S., F.N.I., Superintending Geologist, Geological Survey of India, 27, Chowringhee, Calcutta.

Botany.—Dr. K. Biswas, M.A., D.Sc. (Edin.), F.R.S.E., Superintendent, Royal Botanic Garden, Sibpur, Calcutta.

Zoology and Entomology.—Dr. B. N. Chopra, D.Sc., F.N.I., Assistant Superintendent, Zoological Survey of India, Indian Museum, Calcutta.

Anthropology and Archaeology.—Dr. N. P. Chakravarti, Ph.D., Deputy Director-General of Archaeology in India, New Delhi.

Medical and Veterinary Sciences.—Dr. F. C. Minett, D.Sc., M.R.C.V.S., Director, Imperial Veterinary Research Institute, Mukteswar-Kumaun, U. P.

Agricultural Sciences.—Rao Bahadur Y. Ramchandra Rao, M.A., F.R.E.S., Retired Locust Research Entomologist, 199, Market Road, Visvesvarapuram, Bangalore City.

Physiology.—Prof. B. Narayana, M.Sc., M.B., Ph.D., F.R.S.E., Professor of Physiology, Prince of Wales Medical College, P.O. Bankipore, Patna.

Psychology and Educational Science.—Prof. B. L. Atreya, M.A., D.Litt., Professor of Philosophy and Psychology, Benares Hindu University, Benares.

Engineering and Metallurgy.—N. V. Modak, Esq., B.E., M.I.C.E., M.I.E. (India), M.I.M. and Cy.E., F.R.San.I., J.P., City Engineer, Bombay Municipality, Bombay.

RECORDERS OF SECTIONS:

Mathematics and Statistics.—Dr. B. N. Prasad, M.Sc., Ph.D. (Liverpool), D.Sc. (Paris), F.N.I., Department of Mathematics, University of Allahabad, Allahabad.

Physics.—Dr. R. C. Majumdar, Dr. Phil. Nat., Research Physicist, Bose Research Institute, 93, Upper Circular Road, Calcutta.

Chemistry.—Prof. D. D. Karve, M.Sc., Ph.D., A.I.I.Sc., Professor of Chemistry, Fergusson College, Poona 4.

Geology and Geography.—Dr. Charles Pichamuthu, B.Sc., Ph.D. (Glas.), F.R.S.E., F.G.S., Registrar, University of Mysore, Mysore.

Botany.—Prof. J. C. Sen-Gupta, M.Sc. (Cal.), Ph.D. (Heidelburg), Senior Professor of Botany, Presidency College, Calcutta.

Zoology and Entomology.—Prof. A. B. Misra, D.Sc., D.Phil. (Oxon), F.Z.S., F.R.E.S., Professor and Head of the Department of Zoology, Benares Hindu University, Benares.

Anthropology and Archaeology.—Dr. A. Aiyappan, M.A., Ph.D. (Lond.), F.R.A.I., Offg. Superintendent, Government Museum, Egmore, Madras.

Medical and Veterinary Sciences.—Prof. G. Panja, M.B. (Cal.), D.Bact. (Lond.). Offg. Professor of Bacteriology and Pathology, Calcutta School of Tropical Medicine, Chittaranjan Avenue, Calcutta.

Agricultural Sciences.—Dr. J. K. Basu, M.Sc., Ph.D. (Lond.), Soil Physicist, Sugarcane Research Scheme, Padegaon, Post Nira R. S., District Poona.

Physiology.—K. Mitra, Esq., M.B., D.P.H. (Cal.), D.T.M. & H. (Eng.), F.S.S. (Lond.), Officer-in-Charge, Nutrition Scheme, Government of Bihar, P.O. Bankipore, Patna.

Psychology and Educational Science.—S. K. Bose, Esq., M.Sc., M.A., Assistant Lecturer in Psychology, University College of Science and Technology, 92, Upper Circular Road, Calcutta.

Engineering and Metallurgy.—Prof. Hira Lal Roy, A.B. (Harvard), Dr. Ing. (Berlin), M.I.Ch.E., Professor-in-Charge of the Chemical Engineering Department, College of Engineering and Technology, Bengal, P.O. Jadavpur College, 24-Parganas.

SECTIONAL CORRESPONDENTS:

Mathematics and Statistics.—Sisirendu Gupta, Esq., M.Sc., Lecturer in Applied Mathematics, University College of Science and Technology, 92, Upper Circular Road, Calcutta.

Physics.—Dr. S. C. Sirkar, D.Sc., Department of Physics, University College of Science and Technology, 92, Upper Circular Road, Calcutta.

Chemistry.—S. N. Mukherjee, Esq., M.Sc., Lecturer in Chemistry, University College of Science and Technology, 92, Upper Circular Road, Calcutta.

Geology and Geography.—Dr. A. G. Jhingran, M.Sc., Ph.D. (Durham), Geologist, Geological Survey of India, 27, Chowringhee, Calcutta.

Botany.—Dr. S. M. Sircar, M.Sc. (Cal.), Ph.D. (Lond.), D.I.C., Lecturer in Plant Physiology, Department of Botany, University College of Science and Technology, 35, Ballygunge Circular Road, Calcutta.

Zoology and Entomology.—Mukundamurari Chakravarty, Esq., M.Sc., Lecturer in Zoology, University College of Science and Technology, 35, Ballygunge Circular Road, Calcutta.

Anthropology and Archaeology.—Professor D. Sen, M.Sc., Professor of Geography, Vidyasagar College, 39, Sankar Ghose Lane, Calcutta.

Medical and Veterinary Sciences.—Dr. D. N. Banerjee, M.B. (Cal.), M.D. (Berlin), Officer-in-Charge, Cholera Kidney Enquiry, Indian Research Fund Association and Lecturer in Pathology, Carmichael Medical College, Calcutta.

Agricultural Sciences.—Dr. R. P. Mitra, D.Sc., Senior Assistant Soil Chemist under the Imperial Council of Agricultural Research,

University College of Science and Technology, 92, Upper Circular Road, Calcutta.

Physiology.—Banbihari Chatterji, Esq., M.Sc., M.B., Medical Practitioner and Lecturer in Physiology, University College of Science and Technology, 92, Upper Circular Road, Calcutta.

Psychology and Educational Science.—Suhrid Chandra Sinha, Esq., M.Sc., Department of Psychology, University College of Science and Technology, 92, Upper Circular Road, Calcutta.

Engineering and Metallurgy.—Prof. S. R. Sen-Gupta, Bengal Engineering College, P.O. Botanic Garden, Howrah.

LOCAL SECTIONAL SECRETARIES:

The above Sectional Correspondents, in addition to their duties, acted as Local Sectional Secretaries for the respective sections, excepting for the section of Engineering and Metallurgy, for which the Local Secretaries made the arrangements.

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Prof. P. Parija, M.A., F.N.I., I.E.S., Principal, Ravenshaw College, Cuttack.

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Prof. J. N. Mukherjee, D.Sc., F.C.S., F.R.A.S.B., F.N.I., University College of Science and Technology, 92, Upper Circular Road, Calcutta.

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11. Prof. B. Sahni, Sc.D., D.Sc., F.R.S.
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18. Sir C. V. Raman, Kt., Nobel Laureate.
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10. Dr. Baini Prashad, O.B.E., D.Sc., F.L.S., F.Z.S., F.R.S.E., F.R.A.S.B., F.N.I.
29. Rai Bahadur Dr. S. L. Hora, D.Sc., F.L.S., F.Z.S., F.R.S.E., F.R.A.S.B., F.N.I.

30—41. ***(f) Presidents of Sections*** (*vide* list on p. 4).

(g) Elected by the General Committee.

42. Dr. M. D. Avasare, M.Sc., Ph.D.
43. Prof. B. C. Guha, Ph.D., D.Sc.
44. Prof. H. K. Mookerjee, M.Sc., D.Sc., D.I.C.
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48. Prof. B. N. Singh, D.Sc.

3. SECTIONAL COMMITTEES, 1942-43.

*Names marked with * indicate that they were also Recorders of the respective Sections.*

1. Mathematics and Statistics—

* Dr. S. C. Dhar	.. .. ..	*Convener.*
Dr. B. N. Prasad	.. .. ..	*Recorder.*
Mr. Sisirendu Gupta	.. ..	*Sectional Correspondent.*
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2. Physics—

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Sir C. V. Raman	*Past Presidents who are Ordinary or Honorary Members.*
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† Since deceased.

6. Zoology and Entomology—

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Prof. G. Panja	*Recorder.*
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Capt. S. Datta ..	.. ..	
Dr. Phanindranath Brahmachari	..	
Prof. S. Ramakrishnan	.. ..	
Dr. G. D. Bhalerao	.. ..	

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Dr. V. K. Badami..	.. ..	*Elected Members.*
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Sir T. Vijayaraghavacharya ..	..	
Rao Bahadur G. N. Rangaswami Ayyangar		
Khan Bahadur Mohamad Afzal Husain	..	
Mr. A. K. Y. Narayan Aiyer ..	..	
* Rao Bahadur B. Viswanath ..	..	
Rao Sahib T. V. Ramakrishna Ayyar	..	
Rai Sahib Jai Chand Luthra ..	..	
Mr. K. Ramiah ..	.. ..	
Dr. Nazir Ahmad ..	.. ..	
Mr. N. V. Joshi ..	.. ..	*Past Recorders who are Ordinary or Honorary Members.*
Dr. S. V. Desai .	.. ..	
Dr. A. N. Puri .	.. ..	
Dr. C. N. Acharya	.. ..	
Mr. N. L. Dutt ..	.. ..	

10. **Physiology—**

* Prof. B. Narayana	.. ..	*Convener.*
Mr. K. Mitra ..	.. ..	*Recorder.*
Mr. Banbihari Chatterji	.. ..	*Sectional Correspondent.*
Mr. S. Banerjee ..	.. ..	*Elected Members.*
Dr. R. P. Patel ..	.. ..	
Prof. W. Burridge	.. ..	*Past Presidents who are Ordinary or Honorary Members.*
Lt.-Col. S. L. Bhatia	.. ..	
Sir R. N. Chopra..	.. ..	
* Prof. N. M. Basu..	.. ..	
Dr. W. R. Aykroyd	.. ..	
* Dr. B. B. Dikshit	.. ..	
Prof. B. T. Krishnan	.. ..	
Dr. S. N. Mathur	.. ..	*Past Recorders who are Ordinary or Honorary Members.*
Prof. B. Narayana	.. ..	
Dr. B. Mukerji ..	.. ..	

11. **Psychology and Educational Science—**

* Prof. B. L. Atreya	.. ..	*Convener.*
Mr. S. K. Bose ..	.. ..	*Recorder.*
Mr. Suhrid Chandra Sinha	.. ..	*Sectional Correspondent.*
Dr. G. S. Ghurye	.. ..	*Elected Members.*
Mr. T. K. N. Menon	.. ..	

Dr. N. N. Sen-Gupta ..	..	*Past Presidents who are Ordinary or Honorary Members.*
* Mr. N. S. N. Sastry ..	..	
Prof. G. Bose ..	..	
* Mr. M. N. Banerji ..	..	
Dr. S. C. Mitra ..	..	
Mr. J. M. Sen ..	..	
Mr. K. C. Mukherji ..	..	
Mr. Haripada Maiti ..	..	
* Dr. I. Latif ..	..	
* Dr. Gopeswar Pal ..	..	
Mr. D. Ganguly ..	..	*Past Recorder who is an Ordinary Member.*

12. Engineering and Metallurgy—

* Mr. N. V. Modak ..	..	*Convener.*
Prof. Hira Lal Roy	..	*Recorder.*
Prof. S. R. Sen-Gupta	..	*Sectional Correspondent.*
..............[1]		
Mr. C. C. Inglis ..	..	*Past Presidents who are Ordinary or Honorary Members.*
* Dr. Anant H. Pandya	..	

SUB-COMMITTEE ON 'SCIENCE AND ITS SOCIAL RELATIONS':

Dr. Gilbert Fowler.
Dr. John B. Grant.
Mr. D. D. Kanga.
Dr. Kewal Motwani, Secretary.
Prof. P. Parija, General Secretary (*Ex-officio*).
Mr. A. C. Ukil.

4. LOCAL RECEPTION COMMITTEE.

CHAIRMAN.

Dr. B. C. Roy, M.D., M.R.C.P., F.R.C.S., Vice-Chancellor, Calcutta University.

VICE-CHAIRMEN.

Dr. S. P. Mookerjee, M.A., B.L., D.Litt., Barrister-at-Law, M.L.A., 77, Asutosh Mookerjee Road, Calcutta.
Rai Sir U. N. Brahmachari Bahadur, Kt., M.A., M.D., Ph.D., F.S.M.F., F.N.I., F.R.A.S.B., 19, Loudon Street, Calcutta.
Khan Bahadur Mahmood Hasan, M.A., B.L. (Cal.), M.A., D.Phil. (Oxon), Barrister-at-Law, Vice-Chancellor, Dacca University.

LOCAL SECRETARIES.

Dr. P. N. Brahmachari, M.Sc., M.D., Cardiologist and Physician, Calcutta Medical College.
Dr. D. Chakravarti, D.Sc., Lecturer in Chemistry, Calcutta University.

TREASURER.

Prof. P. C. Mitter, M.A., Ph.D., F.N.I., Palit Professor of Chemistry, Calcutta University.

JOINT TREASURER.

S. N. Mukherjee, Esq., M.Sc., Lecturer in Chemistry, Calcutta University.

MEMBERS.

Adair, Dutt & Co.
(G. Bhattacharyya, Esq.)
Dr. S. P. Agharkar.
Associated Alkali Chemical Industries.
(Sanjib Bhattacharyya, Esq.)

[1] Members elected by the General Committee to serve on the Sectional Committee did not enrol themselves as Ordinary Members for the year.

S. N. Banerjee, Esq.
Bangasri Cotton Mills, Ltd.
(D. N. Dhar, Esq.)
S. M. Basu, Esq.
Bengal Belting Works, Ltd.
(S. C. Dey, Esq.)
Bengal Drugs and Pharmaceutical Works, Ltd.
(N. K. Mitra, Esq.)
S. K. Bhattacharya, Esq.
Bhattacharyya Rubber Works.
(D. Bhattacharyya, Esq.)
B. Birla, Esq.
Dr. D. M. Bose.
Calcutta Chemical Co.
(B. Maitra, Esq.)
N. Chakravarti, Esq.
B. Chatterjee, Esq.
Changrohatta Bone Mills.
(N. C. Gupta, Esq.)
A. Chowdhury, Esq.
Rai J. N. Chowdhury.
Capt. N. N. Dutta.
Sir David Ezra.
G. T. R. Co., Ltd.
(S. Sinha, Esq.)
Dr. J. Ghosh.
Dr. P. K. Ghosh.
A. P. Gooptu, Esq.
H. P. Gooptu, Esq.
Hindusthan Rubber Works, Ltd.
(Rai J. C. Sen Bahadur.)
India Electric Works, Ltd.
(B. K. Rohatgi, Esq.)
Indian Health Institute.
(Dr. B. C. Das.)
D. P. Khaitan, Esq.
Dr. B. C. Law.
Bhabani Charan Law, Esq.
Dr. N. N. Law.
Tarini Charan Law, Esq.
Lister Antiseptic and Dressings Co. (1928) Ltd.
(J. Chakravarti, Esq.)
P. C. Mahalanobis, Esq.
Dr. S. K. Mitra.
Mohini Mills, Ltd.
(M. L. Shah, Esq.)
Dr. P. Neogi.
Sir Hari Sankar Paul.
Sir Asoka Roy.
Satinath Roy, Esq
S. K. Roy & Co., Ltd.
(S. K. Roy, Esq.)
Dr. M. N. Saha.
Dr. B. B. Sarkar.
Scientific Indian Glass Co., Ltd.
B. M. Sen, Esq.
S. P. Sen, Esq.
Sisir Soap Works.
(S. K. Ghosh, Esq.)
Sree Saraswaty Press, Ltd.
(S. N. Guha Roy, Esq.)
Standard Stationery Manufacturers, Ltd.
(Manicklal Dutta, Esq.)
Subarban Bank, Ltd.
(B. C. Das, Esq.)
Union Drug Co., Ltd.

SPECIAL OFFICERS OF THE LOCAL RECEPTION COMMITTEE.

Department.	*Officers.*
Sectional meetings	Dr. D. K. Banerjee.
	Dr. S. G. Chaudhury.
	Mr. S. Chatterjee.
Residence	Anath Nath Basu, Esq.
Volunteers	Dr. S. C. Niyogy.
	Dr. B. Chatterjee.
	Mr. B. Chatterji.
Lady Volunteers	Miss A. Mookerjee.
Refreshments	Dr. P. C. Mitter.
	Dr. P. C. Dutt.
Distribution of badges and leaflets ..	Mr. S. K. Chakrabarty.
	Mr. M. M. Chakravarty.
Reception at Stations	Dr. P. C. Datta.
	Mr. Bibhuti B. Sircar.
Popular lectures	Mr. B. C. Mukherji.
	Dr. P. C. Mahanti.
	Mr. U. Chatterjee.
Enquiries	Mr. S. N. Mukherjee.
	Dr. B. Chatterjee.
	Mr. A. Majumdar.
Reception Hall	Mr. S. K. Chakrabarty.

5. FINANCIAL ARRANGEMENTS FOR THE THIRTIETH SESSION.

The Local Reception Committee made all local arrangements necessary for the transaction of the scientific work of the Meeting and for accommodation of the members of the Congress and the delegates. They raised the total sum of Rs.5,667, and the total expenditure amounted to Rs.3,470-8-6 (*vide* statement of receipts and payments published on p. 45).

The Local Reception Committee has contributed, the whole of its surplus amounting to Rs.2,195-7-6 to the funds of the Association.

6. LIST OF DELEGATES.

A. DELEGATES FROM OUTSIDE INDIA.

American Association for the Advancement of Science.

1. Prof. R. C. Ray.
2. Prof. G. S. Kulkarni.
3. Prof. B. N. Singh.

B. DELEGATES FROM UNIVERSITIES, LEARNED SOCIETIES, STATES AND GOVERNMENT DEPARTMENTS IN INDIA.

Agra University.

1. Dr. B. Ramamurti.
2. Mr. P. D. Swami.

University of Allahabad.

1. Prof. A. C. Banerji.
2. Dr. D. R. Bhattacharya.
3. Prof. K. S. Krishnan.
4. Dr. H. R. Mehra.
5. Dr. B N. Prasad.
6. Dr. Shri Ranjan.
7. Dr. B. K. Singh.

Andhra University.

Dr. P. Suryaprakasa Rao.

Annamalai University.

Dr. S. Ramachandra Rao.

University of Bombay.

1. Dr. A. S. Kalapesi.
2. Dr. R. C. Shah.
3. Dr. K. Venkataraman.

University of Dacca.

1. Dr. K. P. Basu.
2. Prof. N. M. Basu.
3. Mr. H. D. Bhattacharyya.
4. Prof. S. N. Bose.
5. Prof. J. K. Chowdhury.
6. Dr. S. S. Guha-Sarkar.
7. Dr. P. Maheswari.
8. Dr. A. T. Sen.

Nagpur University.

1. Dr. S. C. Dhar.
2. Mr. V. B. Shukla.

Osmania University.

1. Dr. B. K. Das.
2. Mr. Fazle Karim Khan.
3. Dr. Brij Mohan Lal.
4. Dr. N. Ram Lal.
5. Dr. M. Qureshi.
6. Dr. Syed Abdur Rahman.
7. Prof. M. Sayeed-ud-Din.

University of the Panjab.

Mr. Rafi-uz-Zaman Khan.

Patna University.

Prof. B. Narayana.

Indian Botanical Society.

1. Prof. S. P. Agharkar.
2. Prof. Y. Bharadwaja.
3. Dr. N. L. Bor.
4. Dr. H. Chaudhuri.
5. Prof. M. O. P. Iyengar.
6. Prof. G. P. Majumdar.
7. Prof. P. Parija.
8. Prof. B. Sahni.

Indian Statistical Institute.

Prof. P. C. Mahalanobis.

National Academy of Sciences, India.

1. Prof. A. C. Banerji.
2. Prof. D. R. Bhattacharya.
3. Prof. K. S. Krishnan.
4. Dr. H. R. Mehra.
5. Dr. Shri Ranjan.
6. Prof. B. K. Singh.

Mayurbhanj State.

Mr. B. H. Jena.

Indian Research Fund Association.

Lt.-Col. S. S. Sokhey.

Government of Madras (Education and Public Health Department).

1. Dr. A. Aiyappan.
2. Miss M. M. Mehta.

7. PROGRAMME OF THE SESSION.

The Thirtieth Meeting of the Indian Science Congress Association was held at Calcutta from January 2nd to January 4th, 1943.

The inaugural meeting was held on Saturday, January 2nd, 1943, at 10 A.M. in the Applied Chemistry Hall of the University College of Science, Calcutta. Dr. B. C. Roy, M.D., M.R.C.S., F.R.C.P., Vice-Chancellor, University of Calcutta, Chairman of the Reception Committee welcomed the delegates in a speech and opened the Session of the Congress. Pandit Jawaharlal Nehru, the President-elect of the Session, being unable to assume office, Mr. D. N. Wadia, President of the last Session, delivered a short address and conducted the deliberations of the Session.

The Sectional Presidential Addresses were delivered * as follows:—

Sunday, January 3rd: 9 A.M., Psychology and Educational Science; 9-45 A.M., Geology and Geography; 10-30 A.M., Zoology and Entomology; 11-15 A.M., Mathematics and Statistics; 12 Noon, Engineering and Metallurgy †; 4 P.M., Agricultural Sciences †.

Monday, January 4th: 9 A.M., Botany; 9-45 A.M., Physics; 10-30 A.M., Physiology ‡; 11-15 A.M., Medical and Veterinary Sciences; 12 Noon, Anthropology and Archaeology.

Symposia and Joint Meetings of Sections were held as follows:—

Sunday, January 3rd:

10-30 A.M. to 12-30 P.M.

Discussions on	**Held in**
(1) 'Recent progress in Cosmic Ray Physics.'	Section of Physics.

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* In the absence of the Presidents of the following Sections the Addresses were read by one of the Past Presidents of the respective sections as follows:—

Psychology and Educational Science, by Mr. M. N. Banerji; Zoology and Entomology, by Mr. D. D. Mukerji; Physics, by Professor M. N. Saha.

† As the Presidents of these Sections were unable to attend the Session, with the approval of Mr. D. N. Wadia, the Sectional Committee decided to accept the Addresses as read and the copies of the addresses were distributed to the members present.

‡ The Presidential Address for the Section of Chemistry was fixed for delivery at this hour, but the Presidential Address being not received, the Presidential Address for the Section of Physiology scheduled to be delivered at 4-15 P.M. was read by Professor N. M. Basu, Chairman of the Meeting, in the absence of the President of the Section.

Discussions on	Held in
(2) 'Need for a Psychology to replace the Psychologies.'	Section of Psychology and Educational Science.
(3) 'Production and preservation of feed and fodder in war time to meet war needs.'	Joint Meeting of Sections of Agricultural Sciences, Physiology, Medical and Veterinary Sciences, Chemistry and Botany.

3-30 P.M. to 5 P.M.

(4) 'Water resources and soil conservation.' *	Joint Meeting of Sections of Engineering and Metallurgy, Agricultural Sciences, Geology and Geography and Botany. (Continued on January 4, at 3-30 P.M.)

Monday, January 4th:

11-30 A.M. to 1-30 P.M.

(5) 'Teaching of Statistics.'	Joint Meeting of the Section of Mathematics and Statistics with the Indian Statistical Conference.
(6) 'Mathematical theory of elementary particles and their interactions.'	Section of Physics.
(7) 'Should the education of girls differ from that of boys ? '	Section of Psychology and Educational Science.
(8) 'Nitrogen fixation by Blue-Green Algae.'	Section of Botany.
(9) 'Intelligent use and conservation of India's coals.'	Joint Meeting of Sections of Chemistry and Geology and Geography.

4 P.M. to 5-30 P.M.

(10) 'Problem of Work and Rest in Public Institutions.'	Section of Psychology and Educational Science.

* The Discussion on 'Underground water resources' (Sections of Engineering and Metallurgy, Agricultural Sciences, and Geology and Geography) and another on 'Water and soil conservation' (Sections of Engineering and Metallurgy, Agricultural Sciences, and Botany) were amalgamated and the interested Sections participated in the discussion noted above.

Popular Lectures were delivered as follows :—

Saturday, January 2nd, at 5-30 P.M.

'Solar Corona,' by Professor M. N. Saha, F.R.S., Palit Professor of Physics, Calcutta University.

Sunday, January 3rd, at 5-30 P.M.

'Indian Railways and their problems,' by Mr. L. P. Misra, M.I.E., General Manager, Bengal and Assam Railway.

Monday, January 4th, at 5-30 P.M.

'Petroleum, its production and utilization,' by Mr. A. Reid, M.A., B.Sc., A.M.Inst.P.T., Senior Fields Chemist, Assam Oil Co., Ltd., Digboi.

The following Meetings were held during the Session of the Indian Science Congress:—

THE SECTIONAL COMMITTEES met at 11-30 A.M. on Saturday, January 2nd and at 9 A.M. on Sunday, January 3rd and on Monday, January 4th.

THE SUB-COMMITTEE on 'Science and its Social Relations' met at 3-30 P.M. on Saturday, January 2nd.

THE COUNCIL met at 3 P.M. on Saturday, January 2nd.

THE EXECUTIVE COMMITTEE met at 2 P.M. on Friday, January 1st and at 2-30 P.M. on Sunday, January 3rd.

THE GENERAL COMMITTEE met at 4-30 P.M. on Saturday, January 2nd and at 2-30 P.M. on Monday, January 4th.

The following Scientific Societies held their Annual Meetings during the Thirtieth Session of the Congress:—

1. The National Institute of Sciences of India at 3-30 P.M. on Friday, January 1st.
2. The Indian Physical Society at 1-30 P.M. on Saturday, January 2nd.
3. The Indian Psychological Association at 1-30 P.M. on Saturday, January 2nd.
4. The Physiological Society of India at 1-30 P.M. on Saturday, January 2nd.
5. The Indian Botanical Society at 1-30 P.M. on Saturday, January 2nd.
6. The Indian Society of Soil Science at 1-30 P.M. on Sunday, January 3rd.
7. The Institute of Chemistry of Great Britain and Ireland (Indian Section) at 1-30 P.M. on Sunday, January 3rd.

8. The Indian Chemical Society at 1-30 P.M. on Sunday, January 3rd.

The Calcutta Mathematical Society held a special General Meeting at 1-30 P.M. on Saturday, January 2nd.

A Tea Party was given in honour of the Members of the Indian Science Congress by Dr. D. M. Bose, Director, Bose Institute, Calcutta, on Monday, January 4th, at 4 P.M.

8. OPENING PROCEEDINGS.

The Thirtieth Meeting of the Indian Science Congress was opened on Saturday, January 2nd, 1943, at 10 A.M. by Dr. B. C. Roy, M.D., M.R.C.P., F.R.C.S., Vice-Chancellor of the University of Calcutta, in the Applied Chemistry Hall of the University College of Science, Calcutta. The following is the text of Dr. B. C. Roy's speech welcoming the delegates as Chairman of the Local Reception Committee:—

'When a few days ago your energetic General Secretary suddenly approached me and the Syndicate to grant the Indian Science Congress Association facilities for holding its 30th annual session under the aegis of the Calcutta University, I hardly realised that I would have to deliver a speech welcoming the noted group of scientists who have gathered here to-day; if I had known of this implication of his request, I wonder if I would have been so prompt to persuade the Syndicate to grant the request. As soon as the Syndicate accepted the proposition, I was told that I would have to greet you both on behalf of the University and of its Chancellor who unfortunately could not be present here this morning, although I shall presently have the privilege of reading out to you his message of good will.

On behalf of the Reception Committee and of the University, I welcome you, Mr. President, who has come to this much bombed city and with great courage and determination have travelled thousands of miles to fill the vacant Chair of the President-elect, Pandit Jawaharlal Nehru, Chairman of National Planning Committee, who, as you are well aware, is unfortunately unable to preside. I welcome the delegates and all those present here to-day who are interested in the development of science in this ancient land. Ordinarily Calcutta is at its best during this season. The sports, amusements and other festivities which this erstwhile capital of India provides for the visitors, have yearly attracted the pleasure-seekers and the fortune-hunters; even the Departments of the Central Government and their Heads come to Calcutta at this time of the year to join in the ceremonial functions, attend to their duties and enjoy the pleasures which the City affords. Taking advantage of such an assemblage of people from all parts of India, it is customary at this season, to

hold meetings of Associations of various types, social, educational, religious, scientific and political. We regret, however, that, on this occasion, we cannot provide the delegates with any of these pleasures; even the ordinary amenities may be missed. As you are aware, Lucknow was chosen as the venue of this meeting this year, but, at the last moment, it was found difficult to make arrangements in that city; other likely University centres were unsuccessfully approached. As a last resort, the Executive Committee decided to hold the Session here and the Reception Committee had very little time left to make necessary arrangements. The Committee has already notified that this Session should be regarded as meant for business only. This province and Calcutta had hardly emerged from the depression caused by the distress and havoc which resulted from the terrible flood affecting two of the neighbouring districts, when this City was treated to a succession of bombing raids. Naturally, our resources were severely tried and, on behalf of the Reception Committee, I can only crave for your indulgence and request you to accept the " will " for the " deed ".

This Session of the Association, as is its custom, will deal with the work of various departments of Science. This University, as most of you are aware, has for the last thirty years been trying to provide facilities for its students, research workers and professors, to enable them to investigate problems affecting all branches of human thought and endeavour. We were able to provide for subjects dealing with Philosophy and History, Literature and Ethics much earlier than those dealing with Science and Technology. I do not say that we have yet touched the fringe of the problem but the establishment of this Science College gave a great impetus to our men, gifted with initiative and determination and will to conquer, to probe deeply the mysteries of nature and its laws for the benefit of humanity, and such activities have not been merely confined to laboratories. Non-official industrial concerns and the Government were quick to realize the value of the work being conducted here. During the last few years, a large amount of work has been done in the departments of Physics and Applied Physics, of Chemistry and Applied Chemistry, of Zoology and Botany, some of which have obtained universal recognition. Many of these investigations were undertaken at the instance of and with some contributions from the Board of Scientific and Industrial Research of the Government of India, the Bengal Industrial Board, the Geological Survey of India and the Imperial Council of Agricultural Research. Non-official commercial bodies like the Burmah Oil Co. have also sought the help of this institute. As soon as the problems, set before our workers by these agencies, have been satisfactorily solved by them, the results became available to the principals. In this manner, the practical application of science to the affairs of everyday world, serves to make life fuller, wider,

richer and healthier and to secure such human happiness as material things can promote. It is natural, therefore, that at least once every year, the workers in such branches of Science should meet their colleagues from other parts of India and Ceylon, compare notes with them and evolve new truths after consultations and discussions.

As far as possible this University, as I have just indicated in my short review, lays equal stress " on the different manifestations of human spirit, on literature and philosophy, on Art and Religion as well as on Science and Technology ". But when one witnesses the uses made of scientific discoveries for widespread destruction and human slaughter, when every day countries revel in perfecting deadlier and more effective weapons for assassinating thousands of innocents and employ scientific weapons to indulge in an orgy of calculated savagery, the like of which has never been witnessed before, one begins to wonder with Rousseau " if science has corrupted our morals ". Before we attempt to answer this problem, let us consider what we mean by the word "science" and what is implied by the term " morals ".

Science has been defined as an ordered knowledge of natural phenomena and of their inter-relation. Such knowledge has accumulated through centuries by observation of facts, by a correct deduction from such observation and formulation of theories to explain them, by confirmatory experiments to test the theories; any theory which would stand the trial of experiments would become part of scientific truth and knowledge. Such knowledge and such truth were originally used to implement nature, to increase the comforts and security of men. Even among primitive men, such knowledge and observation led to a conception of primitive religion, to a conception that natural phenomena are due to direct and immediate intervention of " Unseen Beings ". How then can such a conception of science and its processes corrupt our morals ? Or have we fallen off from this original conception of our ancestors and have adopted lower standard of values ?

The word "morals" is concerned with values, estimates of the ultimate problems of human conduct and what such conduct ought to be. The ultimate aim of " morals " is to secure the " highest good ", to distinguish between good and evil, to find out if the motives of human action and endeavour are being applied to attain this highest good, this " summum bonum ". If it be the object of science, as it originally was " to increase the comforts and security of men " then science, as originally conceived and developed cannot " corrupt our morals ". If nature's gifts have been developed and perfected by man not for any higher purposes but to enable him to indulge in a blind orgy of destruction and devastation, the blame cannot be laid at the door of science or scientists. The sharp weapon, the knife of the surgeon was forged not to destroy the life of the individual but that the

scientist might use it to save the sufferer from the ravages of a malignant affection; the gunpowder was manufactured not to kill thousands of innocent lives but to blast a hillside to provide a channel of pure drinking water to the thirsty people on the other side of the hill and to provide thoroughfare for the masses: the investigations into the properties of phosphorus were directed not to incorporate it in the preparation of bombs to start conflagration in a market place where the poor live but to provide suitable and ready materials for getting light. Thus it is, that man at the dictate of his animal passion is out to prostitute science and the truths available to science, and thus to suppress and strangle " Truth ". Science has taught that destruction and construction must go together. You cannot destroy unless you are ready to construct. Even so in our human body, destruction of tissue cells are going on every moment of our life to be replaced by new cells and new tissues; if not, a void would be left. If a mad man chooses to utilize scientific knowledge only to destroy and not to construct, he only suppresses the scientific truth and lowers the moral value of things. Einstein said in one place, " The present troubles of the world are due to science having advanced faster than morality: when morality catches up with science, these troubles would end". Sir Sarvapalli Radhakrishnan expressed a similar sentiment when he said that our aim should be to insist on the high mission of science and relate it organically to the central purpose of human life and society, to reconcile religious wisdom with scientific achievements.

Before the renowned scientists who have gathered here to-day, I would place the same proposition. Science is not confined to your laboratories, its truths are to be found in a wider field of human endeavour: social and theological sciences require equal attention from the searchers after truth. For after all, is it not a fact that science, in spite of its apparent sub-divisions, is in truth one; we may, for the convenience of study and research, separate agricultural science from Geology and Botany; but can we look upon them as isolated and distinct one from the other ? Should you not rather consider " the effects of science on the well-being of the community and the effects of social conditions on the Advance of Science " ? If this proposition is accepted and acted upon, science and morality will develop together and we shall emerge into a new world order when Truth and Good will reign supreme.

Once again, on behalf of the Reception Committee and the University, I welcome you to your deliberations. I request you to forget our shortcomings and to accept our good wishes for a successful session of the Association.'

After his address, Dr. B. C. Roy read out the following message from His Excellency Sir John Arthur Herbert, G.C.I.E., Chancellor of the University of Calcutta :

'This session of the Indian Science Congress, the 30th in its long history, is being held in circumstances of considerable difficulty. Your original plan of assembling in Lucknow had to be abandoned, and Bengal considers itself fortunate that the University of Calcutta has found itself able to help you in an emergency and that you are meeting here under the auspices of this famous seat of learning. I regret my inability to open this Congress personally, but as Governor of this Province and as Chancellor of this University I extend a very hearty welcome to all who have foregathered here to attend and take part in your deliberations.

The Japanese have tried to keep you away by peppering Calcutta with bombs. If ever there was an instance of misapplied science, it is this, and the psychologists among you will doubtless agree that the enemy have displayed a singular ignorance of the reactions to be expected from scientists to those loud noises to which their laboratory labours have accustomed them from time to time. I am indeed glad that these attempts to undermine the moral of science have proved so abject a failure.

Our recent air-raids, however, are symptomatic of a wider and more insidious attempt to subvert scientific progress. For a number of years past the Axis Powers have deliberately misdirected the great scientific achievements of modern times, and have thereby attempted the ruthless establishment of the rule of brute force. In consequence we find ourselves confronted to-day by foes who have damped down all the fires of scientific research except those which are conducive to the attainment of their own selfish and deplorable objectives. We have been compelled in some measure to meet their force with greater force, and we shall destroy them by calling mechanical science to our aid in an ever-increasing degree. Our victory, which is certain, will nevertheless entail great material losses and enormous dislocation in almost every sphere of human existence. It is urgent upon us, therefore, not to concentrate upon victory alone, but to look forward also to a stable and effective peace.

We shall not achieve such a peace unless we plan ahead, and although I cannot pretend to be conversant with scientific methods, I am convinced that civilization will be wrecked upon the rocks of disorder and self-interest unless Science can steer the ship clear of these dangers. We look to our scientists to do this, and they themselves are fully aware of the fact that the continued and disinterested search after scientific truth is dependent upon the overthrow of those forces which now seek to stifle scientific advancement. I am confident that they also appreciate the necessity of employing their researches and their talents in the rehabilitation of the world after this deluge, and I sincerely hope that in your deliberations here you will be able to keep constantly in mind, not merely the needs of the present,

but also the requirements of the future. It is with this hope that I send you my good wishes for a successful and a creative Congress session.'

Messages from the British Association for the Advancement of Science and the American Association for the Advancement of Science (sent by Prof. R. C. Ray, a delegate appointed by the Association) were read, and thereafter the President, Mr. D. N. Wadia, delivered his Address.*

The meeting terminated with a vote of thanks to the Local Reception Committee proposed by Prof. S. K. Mitra, General Secretary of the Indian Science Congress Association.

9. OFFICIAL RECORDS.

A. MEETINGS OF THE GENERAL COMMITTEE, THE COUNCIL, THE EXECUTIVE COMMITTEE AND THE SUB-COMMITTEE ON 'SCIENCE AND ITS SOCIAL RELATIONS'.

1. MEETINGS OF THE GENERAL COMMITTEE.

(1) A special meeting of the General Committee was held on January 2nd, 1943, at 4-30 P.M. at the University College of Science and Technology, Calcutta, to discuss 'Science and its Social Relations'.

The President Mr. D. N. Wadia, being unable to be present at the meeting, Mr. A. C. Ukil was voted to the chair.

The Chairman placed the report and the proposals of the Sub-Committee (see minutes of the meeting on page 30) before the meeting and explained the necessity and usefulness of co-ordinated activities in the study of such an important subject, vital to the future welfare of the Indian people.

Dr. John B. Grant further emphasized the obligations of science on human society.

Mr. W. D. West wanted to know how far the ideas of the Sub-Committee could be implemented.

Dr. J. N. Mukherjee thought that one of the immediate tasks of the Sub-Committee would be to initiate more propaganda with regard to the teaching of science to the average layman, and that each year there should be a general discussion on a selected subject, for which speakers should be chosen well ahead of the Congress session.

The Meeting approved of the formation of the following Sub-Committee till the next Annual Meeting, with power to co-opt, four members forming a quorum:—

Mr. D. N. Wadia (Colombo).
Pandit Jawaharlal Nehru (Allahabad).
Dr. J. B. Grant (Calcutta).
Prof. S. K. Mitra (Calcutta).
Prof. P. Parija (Cuttack).
Prof. M. N. Saha (Calcutta).
Prof. B. C. Guha (Calcutta).
Dr. S. C. Mitra (Calcutta).
Prof. D. D. Kanga (Madras).
Dr. Gilbert Fowler (Bangalore).
Dr. C. N. Acharya (Bangalore).
Dr. Kewal Motwani (Madras).
Mr. A. N. Basu (Calcutta).
Mr. A. C. Ukil (Calcutta).
Prof. Benoy Kumar Sarkar (Calcutta).
Prof. Radhakamal Mukherjee (Lucknow).

(2) An ordinary meeting of the General Committee was held at 2-30 P.M. on Monday, January 4th, 1943, at the University College of

* Published in Part II of the Proceedings.

Science and Technology, Calcutta. Mr. D. N. Wadia, the President, was in the chair. The following items of business were transacted:—

1. The minutes of the last meeting of the General Committee held at 2 P.M. on January 5th, 1942, at Baroda were read and confirmed.

2. The following resolution was moved from the chair:—

> The General Committee of the Indian Science Congress Association records its deep sense of disappointment at the enforced absence of Pandit Jawaharlal Nehru who had been elected to preside over this Session of the Science Congress. The Committee further regrets that it has not been possible to secure his Presidential Address for this occasion.

3. The audited accounts for the period, 1st December, 1941 to 30th November, 1942, were approved.

4. The Budget Estimates for the year 1st December, 1942 to 30th November, 1943, were accepted.

5. The following modifications of the Rules and Regulations were adopted:—

(i) *Rule* 2.—The Association shall consist of Ordinary Members, Sustaining Members, Benefactors, Honorary Members and Session Members. (The words 'Sustaining Members' and 'Benefactors' have been added).

(ii) *Rule* 4.—The annual subscription of Ordinary Members shall be Rs.12, (the lines following the first remain unchanged; 'Rs.12' is substituted for 'Rs.10'). (This increase of subscription is for three years only for the present, from the 1st February, 1943 to the 31st January, 1946).

(iii) *Rule* 7(*a*).—Full Session Members—Subscription Rs.12 per Session. ('Rs.12' is substituted for 'Rs.10'). (This increase of subscription is for three years only for the present, from the 1st February, 1943 to the 31st January, 1946).

(iv) *New Rule*—Any Ordinary Member agreeing to pay one additional subscription (Rs.12) during his period of membership shall be called Sustaining Member.

(v) *New Rule*.—Any person paying a lump sum of Rs.500 or more or any institution paying a lump sum of Rs.1,000 or more shall be a Benefactor of the Association, subject to the approval of the Executive Committee. Benefactors shall have all rights and privileges of Ordinary Members during their life time.

An institutional Benefactor shall have the right to nominate one person as Ordinary Member of the Association.

Note.—The two new rules were numbered (6) and (7). The existing numbering of rules following Rule 5 were changed accordingly.

(vi) *Regulation I*(1).—The President delivers a Presidential Address of which ordinarily the cost of printing 16 pages of the Proceedings in its usual form shall be borne by the Inidan Science Congress Association and any author exceeding the limit shall bear the extra cost, provided that in no case the Presidential Addresses shall exceed 25 pages. (The lines following the first which is changed as above remain unchanged.)

As the increase of subscription is for three years only for the present it was pointed out by some members present that the modification proposed in Item 3 of the relevant circular (Rule 5 in regard to payment for Life Membership) was unnecessary and the modification of Rule 5 was withdrawn.

6. The President announced the names of the seven members elected to the Executive Committee under Rule 14, and of the seven members elected to the Council under Rule 18, for the year 1943-44:—

Executive Committee.	*Council.*
1. Prof. S. P. Agharkar, Calcutta.	1. Prof. Y. Bharadwaja, Benares.
2. Dr. H. Chaudhuri, Lahore.	2. Prof. G. P. Majumdar, Calcutta.
3. Prof. B. C. Guha, Calcutta.	3. Prof. H. K. Mookerjee, Calcutta.
4. Prof. P. C. Mitter, Calcutta.	4. Dr. K. L. Moudgill, Trivandrum.
5. Dr. K. G. Naik, Baroda.	5. Prof. Mata Prasad, Bombay.
6. Prof. B. Sahni, Lucknow.	6. Prof. M. Qureshi, Hyderabad (Dn.).
7. Mr. W. D. West, Calcutta.	7. Prof. B. Sanjiva Rao, Bangalore.

7. The President announced that Pandit Jawaharlal Nehru would continue as President-elect for the 31st Session.

He further announced that in case the Executive Committee did not receive any information by the 1st of July, 1943, regarding the services of Pandit Nehru being available, Professor S. N. Bose, Head of the Department of Physics, University of Dacca, would be appointed President of the 31st Session.

8. (*a*) The President announced that the Thirty-first Meeting of the Indian Science Congress would be held at Trivandrum under the auspices of the University of Travancore from January 2 to January 8, 1944.

(*b*) The President announced the names of the Sectional Presidents and Recorders for the Thirty-first Meeting as follows:—

Section.	*President.*	*Recorder.*
1. *Mathematics and Statistics.*	Mr. B. M. Sen, Principal, Presidency College, Calcutta.	Mr. K. B. Madhava, Professor of Mathematical Economics and Statistics, Mysore University.
2. *Physics* ..	Dr. D. S. Kothari, Professor of Physics, University of Delhi.	Dr. K. Banerji, Physics Laboratory, University of Dacca.
3. *Chemistry* ..	Dr. R. C. Ray, Professor of Chemistry, Science College, Patna.	Dr. K. Venkataraman, Mody Professor and Head of the Department of Chemical Technology, Bombay University.
4. *Geology and Geography.*	Dr. A. S. Kalapesi, St. Xavier's College, Bombay.	Dr. B. N. Mukerji, Lecturer in Geography, Calcutta University.
5. *Botany* ..	Dr. T. S. Sabnis, Economic Botanist to the Government of U.P., Cawnpore.	Dr. A. C. Joshi, Assistant Professor of Botany, Benares Hindu University.
6. *Zoology and Entomology.*	Dr. Vishma Nath, Professor of Zoology, Government College, Lahore.	Dr. M. L. Bhatia, Lecturer in Zoology, University of Lucknow.
7. *Anthropology and Archaeology.*	Mr. Verrier Elwin, Patangarh P.O., Dindari Tahsil, Central Provinces.	Dr. (Mrs.) I. Karve, Reader in Sociology, Deccan College, Poona.
8. *Medical and Veterinary Sciences.*	Dr. K. V. Krishnan, Professor of Microbiology, All-India Institute of Hygiene and Public Health, Calcutta.	Mr. M. R. Mahajan, Animal Husbandry Officer, Ajmer-Merwara.

Section.	*President.*	*Recorder.*
9. *Agricultural Sciences.*	Rao Bahadur D. V. Bal, Agricultural Chemist to the Government of Central Province and Berar, Nagpur.	Dr. J. K. Basu, Soil Physicist, Sugarcane Research Scheme, Padegaon.
10. *Physiology* ..	Dr. S. N. Mathur, Lecturer in Physiology, King George's Medical College, Lucknow.	Mr. S. A. Rahman, Professor of Physiology, Medical College, Hyderabad-Deccan.
11. *Psychology and Educational Science.*	Mr. J. Sargent, Educational Advisor to the Government of India, New Delhi.	Mr. S. C. Sinha, Department of Psychology, Calcutta University.
12. *Engineering and Metallurgy.*	Mr. J. J. Ghandy, General Manager, Tata Iron & Steel Co., Jamshedpur.	Prof. Hira Lal Roy, Professor-in-Charge of the Chemical Engineering Department, College of Engineering and Technology, Jadavpur.

9. The following were elected members of the Sectional Committees for the year 1943-44:—

Mathematics and Statistics.	1.	Mr. S. C. Chakravarti, Professor of Mathematics, College of Engineering and Technology, Bengal, Jadavpur.
	2.	Dr. R. C. Majumdar, Research Physicist, Bose Institute, Calcutta.
Physics	1.	Mr. B. C. Mukherjee, Department of Applied Physics, Calcutta University.
	2.	Dr. A. K. Dutta, Department of Physics, University of Delhi.
Chemistry ..	1.	Dr. U. P. Basu, Bengal Immunity Research Laboratory, Baranagore, Calcutta.
	2.	Dr. S. C. Niyogy, Department of Applied Chemistry, Calcutta University.
Geology and Geography	1.	Dr. S. Deb, Post-Graduate Geology Department, University of Calcutta.
	2.	Mr. T. N. Muthuswami, Department of Geology, Presidency College, Madras.
Botany	1.	Dr. B. C. Kundu, Department of Botany, Presidency College, Calcutta.
	2.	Dr. P. K. Sen, Physiological Botanist, Agricultural Research Institute, Sabour.
Zoology and Entomology	1.	Dr. B. C. Basu, Entomologist, Imperial Veterinary Research Institute, Izatnagar.
	2.	Mr. A. C. Mukherjee, Department of Anatomy, Carmichael Medical College, Calcutta.
Anthropology and Archaeology.	1.	Mr. D. Sen, Department of Geography, Vidyasagar College, Calcutta.
	2.	* Dr. P. C. Biswas, Department of Anthropology, University of Calcutta.

* His election has been invalid as he was not an ordinary member of the Association at the time of election.

Medical and Veterinary Sciences.	1.	Mr. A. K. Sen, Director, Laboratories of Biological Research and Experimental Therapy, Bengal Chemical and Pharmaceutical Works, Calcutta.
	2.	Dr. H. N. Ray, Section of Protozoology, Imperial Veterinary Research Institute, Mukteswar.
Agricultural Sciences ..	1.	Dr. K. C. Sen, Officer-in-Charge, Animal Nutrition Section, Imperial Veterinary Research Institute, Izatnagar.
	2.	Dr. S. P. Raychaudhuri, Chemical Laboratory, University of Dacca.
Physiology ..	1.	Dr. P. N. Brahmachari, Cardiologist and Physician, Carmichael Medical College, Calcutta.
	2.	Dr. S. N. Ray, Imperial Veterinary Research Institute, Izatnagar.
Psychology and Educational Science.	1.	Mr. A. N. Basu, Lecturer-in-Charge, Teachers' Training Department, University of Calcutta.
	2.	Dr. N. Mukerji, Teachers' Training Department, University of Calcutta.
Engineering and Metallurgy.	1.	Prof. S. R. Sen-Gupta, Bengal Engineering College, Botanic Garden, Howrah.
	2.	Dr. P. C. Mahanti, Department of Applied Physics, University of Calcutta.

10. The following votes of thanks were unanimously adopted:—

(*a*) To the Chancellor of the University of Calcutta, proposed by the President.

(*b*) To the Vice-Chancellor and the University of Calcutta, proposed by Professor S. K. Mitra.

(*c*) To the Director and the Governing Body of the Bose Institute for kindly allowing the use of their rooms, proposed by Professor B. C. Guha.

(*d*) To the Local Reception Committee, proposed by the President.

(*e*) To the Local Secretaries, proposed by Professor S. K. Mitra.

(*f*) To the Treasurer and Joint-Treasurer of the Local Reception Committee, proposed by Dr. K. Biswas.

(*g*) To the Volunteers and their Leaders, proposed by Professor S. K. Mitra.

(*h*) To the President and Mrs. Wadia, proposed by Professor J. N. Mukherjee.

(*i*) To the Sectional Presidents who attended the Session, proposed by Professor S. K. Mitra.

(*j*) To the General Secretaries, proposed by Dr. D. Chakravarti.

(*k*) To the Treasurer, proposed by Professor S. P. Agharkar.

2. Meeting of the Council.

A meeting of the Council was held at 3 P.M. on Saturday, January 2, 1943, at the University College of Science and Technology, Calcutta. Mr. D. N. Wadia, the President, was in the Chair.

1. The minutes of the meeting of the Council held on January 2, 1942, at Baroda were read and confirmed.

2. Considered the modifications of Rules and Regulations proposed by the Executive Committee for placing before the General Committee.

Resolved that the following alterations be made in the circulated modifications of Rules and Regulations for consideration of the Executive Committee:—

(*a*) That the last sentence—'Sustaining Members shall have all the rights and privileges of Ordinary Members'—of Item 5 as listed in the circular sent to the members containing modifications of Rules and Regulations, be deleted.

(*b*) That the first sentence—'Any person or institution paying a lump sum of Rs.500 or more shall be a Benefactor of the Association, subject to the approval of the Executive Committee'—of Item 6 of the circular as above, be modified as follows:—

'Any person paying a lump sum of Rs.500 or more or any Institution paying a lump sum of Rs.1,000 or more shall be a Benefactor of the Association, subject to the approval of the Executive Committee.'

That the following paragraph be added at the end of the Rule:—

'An Institutional Benefactor shall have the right to nominate one person as Ordinary Member to represent it.'

3. Considered the suggested Rule regarding Associated and Affiliated Societies. (The Rule had been circulated to the Members of the Council and opinions from some of them were received.)

Resolved that Professor S. P. Agharkar, Professor J. N. Mukherjee and Mr. W. D. West be requested to submit a joint note on the proposal clarifying the points raised by some of the members for final consideration by the Executive Committee.

3. Meetings of the Executive Committee.

Nine Meetings of the Executive Committee (including one Emergency Meeting) were held during the year 1942-43. The following are the important items of business transacted. (Only abstracts of the resolutions are given. Routine matters and business reported in the Proceedings of the Meetings of the General Committee are not included.)

1. Rai Bahadur Dr. S. L. Hora was nominated member of the Finance Committee for the Session ending January 31st, 1943. (27-2-42.)

2. Professor K. C. Pandya of St. John's College, Agra, was nominated to represent this Association at the Annual Conference of the National Academy of Sciences held at Agra in February, 1942. (27-2-42.)

3. Invitations were extended to the following Scientific Bodies requesting their representation at the Session of the Science Congress. (27-3-42):—

(1) British Association for the Advancement of Science, London.
(2) American Association for the Advancement of Science, Washington.
(3) Pacific Science Association, California, U.S.A.

4. In regard to the resolutions adopted by the different Sections at the 29th Session of the Congress at Baroda (see page 40 of Part I of the Proceedings of the 29th Indian Science Congress), the following actions were taken. (27-3-42):—

Sections of Chemistry, Physics, and Medical and Veterinary Research—

A copy of the resolution adopted by the above Sections jointly was forwarded to the Secretary of the National Planning Committee and also to the Secretary of the Board of Scientific and Industrial Research.

Section of Engineering—

(*a*) It was decided to see that from amongst persons interested in Engineering at least two names are included in the nominations for election to the Executive Committee and also two names for election to the Council.

(*b*) It was pointed out that the printing of the complete papers cannot be undertaken on account of cost and that reading of papers already published elsewhere is not allowed by the Rules of the Association.

(*c*) The Executive Committee took note of the desirability of including in the programme of the Session an evening popular lecture on an Engineering subject.

5. Professor P. C. Mitter was appointed a member representing this Association on the Governing Body of the Indian Research Fund Association in place of Professor S. P. Agharkar whose term expired in September, 1942. (24-8-42.)

6. A Sub-Committee consisting of the following members was formed to consider ways and means of raising at least Rs.10,000 for the Association. (24-8-42):—

(1) Professor S. P. Agharkar.
(2) Dr. S. C. Law.
(3) Professor P. C. Mitter.
(4) Professor M. N. Saha.
(5) Professor S. K. Mitra } *General Secretaries.*
(6) Professor P. Parija }
(7) Professor J. N. Mukherjee, *Treasurer.*

7. (*a*) Printing of advance copy of Discussions was withheld. (24-8-42.)

(*b*) It was decided to request the Sectional Presidents not to arrange more than two discussions. (24-8-42.)

8. In the absence of Pandit Jawaharlal Nehru, Mr. D. N. Wadia, the previous year's President, was requested to continue in the office and to conduct the deliberations of the 30th Session of the Congress as provided for in Rule 12. (8-10-42.)

9. It was decided to shorten the Session to four days only from January 2, 1943 to January 5, 1943. (8-10-42.)

10. Messrs. Ray and Ray were appointed auditors for auditing the accounts of the Indian Science Congress Association for the year ending 30th November, 1942. (8-10-42.)

11. Dr. A. C. Chatterji and Dr. A. N. Singh were appointed Local Secretaries for the 30th Session of the Congress (due to have been held at Lucknow) and were also co-opted members of the Executive Committee. (27-2-42.)

12. On receipt of the information from the Registrar of the Lucknow University by the middle of November, 1942, that it would not be possible for the organizers there to arrange for the Session to be held in January, 1943, the University of Calcutta was approached to invite the Session under its auspices. (27-11-42.)

13. Consequent upon the change of venue of the Session from Lucknow to Calcutta Dr. P. N. Brahmachari and Dr. D. Chakravarti were appointed Local Secretaries for the 30th Session of the Congress at Calcutta and were co-opted members of the Executive Committee. (23-12-42.)

14. The Sectional Correspondents were requested to act as Local Sectional Secretaries at the 30th Session of the Congress at Calcutta. (23-12-42.)

15. Mr. D. N. Wadia and Professor S. K. Mitra represented the Association as Additional Vice-President and as Additional Member respectively on the Council of the National Institute of Sciences of India for the year 1942.

16. The following contributions were thankfully received:—

(1) Calcutta Chemical Co., Ltd.—Rs.290, being additional subscription.

(2) Bengal Chemical and Pharmaceutical Works, Ltd.—Rs.250, being donation.
(3) Tata Iron and Steel Co., Ltd.—Rs.5,000, being donation.

4. Meeting of the Sub-Committee on 'Science and its Social Relations'.

A meeting of the Sub-Committee on 'Science and its Social Relations', was held at 3-30 P.M. on January 2nd, 1943, in the Applied Chemistry Hall, University College of Science and Technology, Calcutta, with Mr. D. N. Wadia, in the chair.

1. Apologies for unavoidable absence were received from Dr. K. Motwani, Secretary of the Sub-Committee.

2. Mr. Ukil gave the following summary of the genesis and work of this Sub-Committee up to date:—

'In 1938, on the initiative of Dr. C. N. Acharya of the Indian Institute of Science, Bangalore, the Indian Science Congress Association appointed the following committee to make proposals for establishing a Sub-Committee on Science and its Social Relations in India, on lines similar to those followed by the sister organizations in Europe and America, with the following members:—

(1) The President.
(2) The President-elect.
(3) Prof. S. P. Agharkar (Convener).
(4) Sir T. Vijayaraghavacharya.
(5) Dr. C. N. Acharya.
(6) The General Secretaries.

The Council of the Indian Science Congress approved of forming the Sub-Committee and placed its recommendations before the General Committee of the Science Congress at its meeting at Lahore on the 8th January, 1939. The General Committee, while ratifying the recommendations of the Council, decided to circulate the matter to the members of the General Committee for opinion.

At the Madras Session in January, 1940, the idea was approved and a Sub-Committee consisting of the President, one General Secretary, and three other members, with power to co-opt, was formed for the purpose of—

(*a*) suggesting to the Executive Committee topics for joint discussions and lectures, etc. relating to the influence of Science on Society in India;
(*b*) formulating proposals for collecting data and taking necessary steps to put into effect such proposals, under the authority of the Executive Committee, relating to the effect of Science on Society in India and matters incidental thereto.

The General Committee, at this session, elected Dr. C. N. Acharya (Bangalore), Prof. D. D. Kanga (Madras) and Mr. Basiswar Sen (Almora) as members. Principal P. Parija, one of the General Secretaries, was appointed to serve on the Sub-Committee. Dr. J. B. Grant, Dr. Kewal Motwani and Dr. Gilbert J. Fowler were later co-opted as members of the Sub-Committee.

Dr. J. B. Grant's lecture on "The future of University Social Sciences seen through Public Health" related to one of the subjects within the scope of the programme of the Sub-Committee.

"Reasons for the lag in India of the utilization of medical knowledge by the individual and initial steps towards solving them" was selected as the next year's topic for joint discussion at the Benares Session (1941). Prof. D. D. Kanga presided. Mr. A. C. Ukil, President of the Medical and Veterinary Research Section of this session, opened the discussion and Lt.-Col. A. C. Chatterjee, I.M.S., Mr. K. N. Bagchi and others participated in the discussion. Mr. A. C. Ukil was co-opted a member of

Sub-Committee and Dr. K. Motwani was elected the Secretary. The following Resolution outlining the scope and activities of the Sub-Committee was moved by Dr. J. B. Grant and carried:—

"Whereas the Indian Science Congress has recently included among its objectives an examination of the influence of scientific advances upon Society in India;

And whereas this objective requires a reviewing of the progress, inter-connections and directions of advance in the physical, chemical, biological and social sciences and an appraisal of the extent to which the results of such scientific investigations have been applied so as to meet the requirements and promote the welfare of the huge populations in India, both rural and urban;

And whereas there appears to be a considerable lag in the application of scientific knowledge to the life of the people in India, with consequent serious drawbacks to their general welfare,

Therefore, be it resolved that the Indian Science Congress authorises the Sub-Committee on Science and its Social Relations to go fully into the question of the above lag existing in India in each of the major fields of public administration having to do with the utilization of scientific knowledge for advancing the welfare of the people, so that the extent and underlying causes for such lag may be determined and suitable measures may be recommended for overcoming the same."

It was also decided that in case the Sub-Committee met with difficulties in securing the co-operation of the Universities and administrative units of the Government, it would approach the Executive Committee for such help as it may render. In conformity with this, the Secretary of the Sub-Committee forwarded a copy of Mr. Ukil's Presidential Address to the administrative heads of various Provinces and States in India.

It was further decided to ask the Sectional Presidents of future sessions of the Indian Science Congress to devote, where possible, a portion of their addresses to the social aspects of the various subjects they dealt with.

During 1941, the Executive Committee invited Dr. Kewal Motwani, the Secretary of the Sub-Committee, to deliver a public address on "Science and Indian National Reconstruction", at the ensuing session to be held at Baroda in January, 1942. The address was later published by the Indian Science Congress Association and circulated to the members of the General Committee of the Association.

At the Baroda Session, in January, 1942, the Executive Committee resolved to set apart one evening, during the future sessions of the Congress, for a general meeting of the members and delegates for discussion on Science and its Social Relations, to publish the name and the personnel of the Sub-Committee in all its Bulletins, lists and official programmes in future, and also made an annual appropriation of Rs.100 to enable the Sub-Committee to carry on its work.

In view of the Inter-University Board of India passing a resolution, recommending to Indian Universities introduction of Sociology as an undergraduate subject, the Sub-Committee conducted a survey of the status of Sociology in the Indian Universities, with a view to finding out the action that was intended to be taken to implement the resolution of the Inter-University Board.

It was about this time that Dr. Motwani began to be interested in the establishment of a National Academy of Social Sciences and wanted the Indian Science Congress to sponsor the same. Dr. J. B. Grant and Mr. A. C. Ukil, two members of the Sub-Committee, did not support Dr. Motwani in taking a step, which they considered premature, without giving the Sub-Committee a chance to explore the possibilities of obtaining further information by a small-scale experiment. Dr. Grant and Mr. Ukil

were of the opinion that further renewed efforts should be made to remodel the Sub-Committee and to work along lines chalked out at the Benares session of the Congress before starting an independent Academy.

The President of the Indian Science Congress, Mr. D. N. Wadia, has further explained the idea of establishing a National Academy of Social Sciences, as proposed by Dr. Motwani, in his Presidential Address on the 2nd January, 1943, and he has proposed the appointment of an Expert Committee to suggest ways and means of bringing this Academy into being.'

3. Dr. J. B. Grant, while supporting the desirability of the establishment in India of an Academy of Social Sciences, thought that its establishment must be preceded by the fulfilment of three conditions: (1) a survey of the present situation of the teaching of Social Sciences in Indian Universities, (2) the existence of a sufficient minimum of Social Science organizations to give substance to an Academy that otherwise might prematurely die and thereby detrimentally affect the future growth of the Social Sciences in India, and (3) the termination of the war. He pointed out that the interest of the Indian Science Congress in the establishment of such an Academy would, in no way, decrease its own responsibility towards assisting in the solution of the lag between science and its social utilization. He proposed that, in recognition of this responsibility, the Sub-Committee should continue to function, if and when the proposed Academy was established.

4. The President and the other members present agreed to this proposal and suggested the formation of the current year's committee on a wider basis. The committee will be asked to choose the subjects for study and work on them with the approval of the Executive Committee of the Indian Science Congress. This year's committee will also be asked to express an opinion on the feasibility of establishing an independent Academy of Social Sciences of India. Dr. Motwani's report for the year 1942 was placed before the Sub-Committee and recorded.

5. Dr. S. K. Mitra, General Secretary of the Indian Science Congress Association, read a letter from Mr. Kewalram Chellaram of Hyderabad, Sind, offering a sum of Rs.2,000 (two thousand only) to the Indian Science Congress to enable Dr. K. Motwani to deliver a series of three lectures on (1) the new world of science, (2) impact of science on Indian Society, (3) science and Indian National Reconstruction, at the Indian Universities in order to bring the significance of the social aspects of science to the notice of people connected with higher studies in this country.

Dr. Mitra also read a letter from Dr. Fowler suggesting as a beginning that interested individuals in the several Universities should be approached and arrangements made for them to become actively engaged as Readers or Research Scholars in the social sciences to form the nucleus around whom like-minded students may be attracted.

It was resolved that the Sub-Committee for the year 1943 be requested to express an opinion on the above subjects and forward the same to the Executive Committee.

B. RESOLUTIONS ADOPTED BY SECTIONS.

Section of Anthropology and Archaeology.

1. That a scheme for preparing an exhaustive list of prehistoric sites in India be worked out in consultation with the Archaeological Survey of India, Archaeological Departments in the Indian States and Indian Universities.

It was suggested that initially a Sub-Committee be formed to work out the details of the scheme which should consist of—

(*a*) Director-General of Archaeology in India or his nominee;
(*b*) Director of Archaeology, Mysore;
(*c*) Director of Archaeology, Hyderabad;

(*d*) Representatives of premier Universities of India;
(*e*) Representatives of principal Museums in India.

2. That the study of Prehistoric Archaeology in India, especially of the Stone Age, be taken up in right earnest after the war and that the Central and Provincial Governments as well as the different Universities of India be approached to encourage such studies by endowing scholarships and fellowships and by providing other facilities to the workers in the field.

3. That a committee be formed to devise ways and means of compiling a volume of scientific papers in commemoration of the Centenary of James Prinsep and the 160th Anniversary of the Royal Asiatic Society of Bengal during 1943-44.

The following names were suggested, with powers to co-opt:—

1. Rao Bahadur K. N. Dikshit, Director-General of Archaeology;
2. Dr. N. P. Chakravarti, Deputy Director-General of Archaeology;
3. Dr. K. Nag, Honorary Secretary, Royal Asiatic Society of Bengal;
4. Dr. B. S. Guha;
5. Prof. K. P. Chattopadhyaya;
6. Prof. A. S. Altekar;
7. Dr. V. S. Sukthankar;
8. Dr. R. C. Majumdar;
9. The Hon'ble Mr. Justice N. E. Edgley;
10. The Hon'ble Sir Maurice Gwyer;
11. Dr. P. C. Biswas } *Joint Secretaries*;
12. Dr. B. K. Chatterjee } *Joint Secretaries*;
13. Prof. D. Sen } *Joint Secretaries*;
14. Mr. Verrier Elwin;
15. Mr. G. Yazdani;
16. Dr. S. N. Sen;
17. Dewan Bahadur K. S. Aiyangar;
18. Dr. M. H. Krishna.

Sections of Medical and Veterinary Sciences, Chemistry, Botany and Physiology (at a joint meeting).

The Indian Science Congress Association draws the attention of the Government and people of India to the seriousness of the food situation in the country, both for human beings and farm animals, and in order to strengthen the food front resolves that a body of experts in agricultural and animal husbandry, nutrition, technology, geography, several branches of economic and political science, biology and physiology, transportation and price behaviour be formed at the Centre and in the Provinces and States in India. The object of this body would be to study the food problem in its inter-related spheres on a regional basis, to pool the knowledge for purposes of planning and to co-ordinate activities for All-India and inter-provincial purposes. It will be necessary to secure the help of the inter-connected administrative departments of Agriculture, Communications, Drainage and Irrigation, Industries, and Public Health, where necessary. This body would also find out alternative sources and substitutes for essential foods whose supply has been short.

A Memorandum relating to the above resolution as approved of by the meeting is given below.

1. More land from the so-called culturable waste and some reappropriated from the area under non-food crops should be brought under cultivation of food crops. The amount of culturable waste and current fallow should be reduced to the minimum.

2. In order to achieve immediate results, locally produced manure, irrigation and drainage facilities should be given to the cultivators free or at a nominal cost wherever possible.

3. A suitable crop-planning scheme should be adopted for every Province before the next *kharif* season, so that both human food crops and, what is also important, fodder crops for working and for milch cattle can be grown. A proper allotment of land must be made so that we get regional self-sufficiency in as many areas as possible.

4. Every incentive should be given to produce, preserve and bring into the market all kinds of animal products such as milk, meat, eggs and fish. An abundant fish supply could be assured to Provinces having extensive coastal and riverain areas which would meet the requirements of a protein food of high biological value. There is also a large scope for the growing of vegetables.

5. Special attempt should be made to increase the milk production of the country. If increased fodder supply is available, it is possible to increase the milk production in the country by 5–10% in a year which will meet the ordinary demands of *ghee* for the army without dislocating the civil needs.

6. It is essential in fact that there should be organized planning as regards production and conservation, transport and marketing while there should be a minimum price guarantee to the producer by the help of subsidies if required.

7. Effective steps should be taken to prevent adulteration of food-stuffs.

8. Suitable educative work should be undertaken against boarding, misuse and waste of food, and to propagate improved methods of cooking for the conservation of nutritive ingredients.

Sections of Geology and Geography, Engineering and Metallurgy, Agricultural Sciences and Botany (at a joint meeting).

1. For the purposes of industrial and agricultural utilization of water, and of sanitary and other uses of drainage and human consumption of water a systematic survey of the water resources including underground sources of India should be undertaken by Government through the Geological Survey of India and such other bodies whose co-operation will be helpful.

2. For purposes of land utilization and soil conservation an erosion survey should be carried out by the Imperial Council of Agricultural Research along with the scheme of All-India Soil Survey with such co-operation as the Geological Survey and provincial Forestry and Agricultural and Botanical Departments may offer.

10. RULES AND REGULATIONS.

RULES.

1. The name of the Association shall be the Indian Science Congress Association, and its objects shall be the advancement of Science in India by the annual holding of a Congress and the doing of all such things as are incidental or conducive to the above object, including—

(*a*) the holding and management of funds and property;

(*b*) the acquisition of rights and privileges necessary or convenient for the object of the Association;

(*c*) the management, development, improvement, disposal and sale of all and any parts of the property of the Association.

2. The Association shall consist of Ordinary Members, Sustaining Members, Benefactors, Honorary Members and Session Members.

3. Ordinary Members of the Association shall have the right to contribute papers for reading at the Session of the Congress, to receive free of charge all publications issued by the Association, and to fill any office in the Association on being duly elected thereto.

4. The annual subscription of Ordinary Members shall be Rs.12. The subscription shall become due on the 1st February of each year and

shall only be effective as a payment for Ordinary Membership subscription if received before the 15th July of the year.

5. Any Ordinary Member may compound for the payment of all future annual subscriptions by the payment in a single sum of Rs.150.

6. Any Ordinary Member agreeing to pay one additional subscription (Rs.12) during his period of membership shall be called Sustaining Member.

7. Any person paying a lump sum of Rs.500 or more or any institution paying a lump sum of Rs.1,000 or more shall be a Benefactor of the Association, subject to the approval of the Executive Committee. Benefactors shall have all rights and privileges of Ordinary Members during their lifetime.

An institutional Benefactor shall have the right to nominate one person as Ordinary Member of the Association.

8. Honorary Members shall have all the rights and privileges of Ordinary Members.

Honorary Members, the number of whom shall be limited to fifteen at any one time, shall be persons eminent for their contributions to Science or persons who have rendered conspicuous services to the cause of Science in India.

Honorary Members shall be unanimously nominated by the Executive Committee subject to confirmation by the Council and the General Committee at its annual meeting. Not more than one Honorary Member shall be elected in any year.

9. There shall be three classes of Session Members:—

(*a*) Full Session Members—subscription Rs.12 per Session.
(*b*) Associate Session Members —subscription Rs.5 per Session.
(*c*) Student Session Members—subscription Rs.2 per Session.

10. Full Session Members shall have the right to contribute papers for reading at the Session of the Congress, and to receive free of charge all publications issued by the Association relating to the Session of the Congress of which they are Members.

Associate and Student Session Members shall have the right to submit papers for reading at the Session of the Congress of which they are Members, provided such papers be communicated through an Ordinary or an Honorary Member of the Association.

A Student Member shall before admission be duly certified by the head of his Institution to be a *bona fide* student.

Associate and Student Session Members shall receive free of cost the Abstracts of Papers contributed for the Session of which they are members.

11. The official year of the Association shall commence from the 1st of February.

12. There shall be Officers of the Association consisting of the Members of the Executive Committee and Presidents and Recorders of Sections.

13. Only Ordinary and Honorary Members shall hold office in the Association.

14. The term of office of all Officers of the Association except the President shall commence from the beginning of the official year and shall extend until the assumption of office by their successors, appointed in accordance with the provisions of these Rules. The President shall assume office on the opening day of the Annual Congress following the one at which he is appointed, and shall continue to hold office until the assumption of office by his successor.

15. There shall be an Executive Committee which shall carry on the administrative work of the Association and submit such questions as it thinks desirable to a General Committee at its Annual Meeting during the Session of the Congress or at a Special Meeting of which due notice shall have been given.

16. The Executive Committee shall consist of the President, the President-elect for the following year, the two General Secretaries, the

Treasurer and seven Members, Ordinary or Honorary, elected by the General Committee. For the purpose of this election any Ordinary or Honorary Member may propose the name of an Ordinary or an Honorary Member for election to the Executive Committee. Such proposal must be seconded by another Ordinary or Honorary Member and must reach the General Secretary before the 15th September. The Executive Committee shall circulate these names, together with such other names, not exceeding three, as it may suggest, to all Ordinary and Honorary Members for election by ballot. The ballot papers will be scrutinized by the President or his nominee and the General Secretaries, and the results of the ballot will be announced at the meeting of the General Committee.

The Executive Committee shall co-opt as Members at least one and not more than two Local Secretaries for the ensuing Session of the Congress.

17. The Executive Committee shall have full power to transact all business in cases of emergency, notwithstanding any limitations hereinafter laid down, and to deal with all matters not otherwise provided for in these Rules, including the making of such Regulations as may appear conducive to the good administration of the Association and the attainment of its object; provided always that such Regulations be not inconsistent with anything contained in these Rules, that they be reported for the information of the next meeting of the General Committee, and that they be subject to rescission or alteration by the Executive Committee or by any meeting of the General Committee.

18. There shall be a General Committee which shall consist of all Ordinary and Honorary Members of the Association.

19. The General Committee shall meet at least once during each Session of the Congress, preferably, in the middle of the Session.

20. There shall be a Council which shall consist of all Members of the Executive Committee, and all such Ordinary and Honorary Members of the Association as have held office as President, General Secretary, Treasurer, or Managing Secretary of the Association, the Sectional Presidents for the ensuing Session, and in addition seven Members of the Association, Ordinary or Honorary, elected by the General Committee. For the purpose of this election any Ordinary or Honorary Member may propose the name of an Ordinary or an Honorary Member for election to the Council. Such proposal must be seconded by another Ordinary or Honorary Member and must reach the General Secretary before the 15th September. The Executive Committee shall circulate these names, together with such other names, not exceeding three, as it may suggest, to all Ordinary and Honorary Members for election by ballot. The ballot papers will be scrutinized by the President or his nominee and the General Secretaries, and the results of the ballot will be announced at the meeting of the General Committee.

21. The function of the Council shall be to act as a body of advisers to be consulted by the Executive Committee on important questions of policy or scientific import.

22. There shall be a President who shall be nominated by the Executive Committee and whose nomination shall be submitted to the General Committee at its Annual Meeting during the Session of the Congress for confirmation.

23. There shall be two General Secretaries (one of whom shall be resident in Calcutta) who shall be nominated by the Executive Committee and whose nomination shall be submitted to the General Committee at its Annual Meeting during the Session of the Congress for confirmation.

24. There shall be a Treasurer who shall be nominated by the Executive Committee and whose nomination shall be submitted for confirmation to the General Committee at its Annual Meeting during the Session of the Congress.

25. The term of office of each General Secretary and of the Treasurer shall be for a period of five years following the confirmation of the appointment of any one of them, and each of them shall be eligible for re-appointment.

26. In the event of a vacancy amongst the General Secretaries and the Treasurer occurring between two Sessions of the Congress the Executive Committee shall have power to appoint a General Secretary or the Treasurer for the period up to the termination of the next Session of the Congress.

27. There shall be a Local Secretary or Local Secretaries for each Session of the Congress who shall be appointed by the Executive Committee.

28. There shall be a Local Committee for each Session of the Congress which shall be appointed by the Executive Committee.

29. The Local Secretary, or Secretaries, and the Local Committee shall jointly, on behalf of and in consultation with the Executive Committee, make all necessary arrangements for the holding of the Session of the Congress.

30. For the purpose of scientific deliberation during the Session of the Congress there shall be such Sections corresponding to different branches of science as may from time to time be constituted by the General Committee on the recommendation of the Executive Committee. It shall be competent for any Section after the first day's meeting to hold its scientific meetings in sub-sections for the purpose of dealing separately with different groups of papers submitted to that Section. A separate chairman may be appointed by the Sectional President in consultation with the Sectional Committee to preside over each sub-section.

31. There shall be in each Section a President and a Recorder who shall be appointed by the Executive Committee. In addition there shall be a Sectional Correspondent and a Local Sectional Secretary who shall be appointed by the Executive Committee.

32. In each Section there shall be Sectional Officers, namely, a President, a Recorder, a Sectional Correspondent, and a Local Sectional Secretary. The President and the Recorder shall be the chief executive officers of the Section. They shall have power to act on behalf of the Sectional Committee in any matter of urgency which cannot be brought before the Sectional Committee for consideration, and they shall report such action to the Sectional Committee at its next meeting.

The work of each Section shall be conducted by a Sectional Committee which shall be constituted as follows:—

(*a*) Sectional Officers.
(*b*) All Ordinary and Honorary Members of the Association who have been Presidents or Recorders of the Section.
(*c*) Two Members of the Association, Ordinary or Honorary, elected by the General Committee at its Annual Meeting during the Session of the Congress.

The Sectional President shall preside over all meetings of the Section and of the Sectional Committee. He shall be the convener of the meetings of the Sectional Committee. His ruling shall be final on all points of order that may arise.

The Sectional Recorder shall act as the Secretary of the Sectional Committee, and shall maintain a proper record of the proceedings of the Sectional Committee and of the Section in a book provided for the purpose. He shall be responsible for the punctual transmission to the General Secretary of the recommendations adopted by the Sectional Committee, and of resolutions adopted by the Section.

The Sectional Correspondent shall be resident at the headquarters of the Association, and shall be responsible for preparing for the press the material relating to his Section, according to the instructions of the Sectional President.

The Local Sectional Secretary shall be resident in the locality where the Annual Session is held, and shall be responsible for all local arrangements for the work of his Section, and for arranging the Sectional excursions in consultation with the Local Secretaries.

33. The Sectional Committee shall meet on the opening day of each Session of the Congress, and daily thereafter during the Session before the meeting of the Section unless otherwise determined at a meeting of the Sectional Committee.

In the absence of the Sectional President from any of its meetings the most senior member of the Sectional Committee present shall take the chair.

In their meeting on the opening day they shall

(*a*) nominate a Sectional President and a Sectional Recorder for the ensuing year for the consideration of the Executive Committee;
(*b*) determine the detailed arrangements for the Sectional meetings;
(*c*) select the papers to be read and discussed;

and in their meetings during the Session they shall also

(*d*) nominate a Sectional Correspondent and a Local Sectional Secretary for the ensuing year for the consideration of the Executive Committee;
(*e*) determine the contents of the Sectional records in the Proceedings in accordance with Rule 32(*e*);
(*f*) consider means of improving the scientific work of the Section, and make suggestions to the Executive Committee whenever considered necessary;
(*g*) select topics for discussions at the next Session of the Congress and make necessary arrangements (*i*) through the President of the Section concerned for discussions within a Section, and (*ii*) through the Sectional President who has initiated the proposal for a discussion in which more than one Section will participate.

34(*a*) All papers submitted for reading at the next Session of the Congress shall be forwarded to the General Secretary so as to reach him not later than September 15th of the calendar year preceding the Session of the Congress at which the papers are intended to be read, provided that this date may be changed by the Executive Committee for special reasons.

(*b*) Any paper submitted for reading at the Session of the Congress shall be accompanied by an abstract in triplicate.

(*c*) All papers submitted for reading at a Session of the Congress shall be checked by the Sectional Correspondent concerned or by such person or persons appointed by the General Secretary. The papers together with a copy each of the abstracts shall then be sent to the Sectional President concerned for refereeing and acceptance. Decisions with regard to acceptance or rejection of any paper shall be final and all reports confidential.

(*d*) No paper published elsewhere shall be accepted.

(*e*) Only abstracts of the papers received by the General Secretary before September 15th in accordance with Rule 32 (*a*), (*b*) and (*c*) shall be printed in Part III of the Proceedings. In exceptional circumstances, abstracts of papers received after that date and read before the Section if specially recommended by the Sectional Committee, may be printed in Part IV.

35. The Proceedings of the Indian Science Congress Association shall be published in one volume in four separate parts, as follows:—

I. To contain the list of officers, the Proceedings of the opening meeting (except the General Presidential Address) and all official matters.

II. To contain the Presidential Addresses. To be distributed to those present at the meeting after the addresses have been delivered, and to absent Ordinary, Honorary and Full Session Members by post after the meeting.

III. To contain the abstracts of papers to be read before the Sections which are received before September 15th in accordance with Rule 32 (*a*). No abstracts shall be included in this volume from authors who have not already enrolled themselves as Members of the Association. To be distributed in advance of the meeting to all Members of the Association.

IV. To contain the discussions, late abstracts accepted in accordance with Rule 32 (*e*), the list of members and the index.

36. The following procedure shall be observed for the making of any addition to or alteration in the Rules of the Association:—

(i) Proposals for additions to and alterations in the existing Rules may be placed at any time before the General Committee by the Executive Committee.

(ii) (*a*) Proposals for additions to and alterations in the existing Rules by any Ordinary or Honorary Member of the Association shall be sent to one of the General Secretaries so as to reach him two full months before the meeting of the General Committee in which they are to be moved.

(*b*) One of the General Secretaries shall circulate such proposals to all Ordinary and Honorary Members of the Association at least one full month before the meeting of the General Committee.

(*c*) Any amendments to the proposals shall be sent by any Ordinary or Honorary Member of the Association to one of the General Secretaries so as to reach him at least a fortnight before the meeting of the General Committee.

(*d*) The proposals together with any amendments shall be brought up before the meeting of the General Committee at its Annual Meeting during the Session of the Congress together with any remarks of the Executive Committee and declared carried if accepted by a two-thirds majority of the constituent Members present and voting at the meeting.

(Adopted the 5th January, 1931. Revised the 5th January, 1935, the 6th January, 1936, the 5th January, 1937, the 8th January, 1939, the 6th January, 1940, the 5th January, 1942 and the 4th January, 1943.)

REGULATIONS.

I. Sectional Officers.

(1) The President delivers a Presidential Address of which ordinarily the cost of printing 16 pages of the Proceedings in its usual form shall be borne by the Indian Science Congress Association and any author exceeding the limit shall bear the extra cost, provided that in no case the Presidential Addresses shall exceed 25 pages. The time available for delivery of the Presidential Address shall usually not exceed 45 minutes. The manuscript of the address, ready for the press, should be received by the General Secretary before October 15th of the calendar year preceding the Session of the Congress at which the address will be delivered, provided that this date may be changed by the Executive Committee for special reasons. It should be accompanied by 12 copies of a short popular summary (about 500 words) for issue to the lay press. The time and date of the delivery of the President's Address will be

communicated before the meeting of the Congress. No two Presidential Addresses will be delivered at the same time.

(2) The President shall be entitled to receive 30 copies of his address without charge, and additional copies at the cost of reproduction.

(3) Railway fares, postage, clerical, or other expenses incurred by the Sectional Presidents will not be paid by the Association.

(4) The following procedure is adopted for the collection of papers for the Sections:—

About the middle of April a number of copies of a printed circular will be forwarded to the President of each Section who may arrange to send these to workers in that branch of science with which his Section is concerned, requesting them to contribute papers for reading before the next meeting of the Congress.

The circular will contain a clause inviting such workers as are not yet Ordinary Members of the Association to join as such. Particular note should be taken of the fact that no new Ordinary Members are enrolled after the 15th July of the year.

In the case of joint papers, each author must be a Member of some category.

(5) The President referees, either in person or by proxy, the papers received for reading before his Section in accordance with Rule 32.

Abstracts should be limited, except in very special cases, to about 200 words. Long abstracts should be reduced by the President. References to literature in abstracts should be avoided as far as possible and when given should conform to the system of abbreviations used by the Association.

The contents of all abstracts should be carefully checked by the Sectional Correspondent concerned or by such person or persons appointed by the General Secretary, and the abstracts shall then be sent to the Sectional President for his final scrutiny and approval.

Joint discussions on related papers may be held. Authors of papers should be informed of the time allotted by the President to the reading of their papers. An author contributing more than one paper should be asked to specify which of them he would prefer to read at the meeting.

(6) The President, in consultation with the Local Sectional Secretary, shall make arrangements for such local Sectional excursions as seem desirable. Due notice shall be given to the General Secretaries of all such arrangements.

(7) The President and the Recorder should, in consultation with other members of the Sectional Committee, make proposals to the General Secretary regarding the programme of the Section. Such proposals should reach the General Secretary not later than the 1st November, so as to enable the necessary details to be entered in the programme. General discussions on questions of importance, held either by a single Section or jointly by two or more Sections, should be encouraged.

The Sectional Presidents concerned shall communicate to the General Secretary before the end of July the titles of such discussions, the names of the speakers and such further information as may be considered necessary.

The Papers, together with three copies of abstracts, to be read by the contributors at a discussion shall be sent to the General Secretary on or before the 15th September of the preceding calendar year by the Sectional President concerned.

The materials relating to a discussion, in a form ready for the press, shall be communicated to the General Secretary within a month from the date on which the discussion takes place; the material not received by the General Secretary within this period shall not be published.

The President and the Recorder of the Section arranging a discussion shall carry out the necessary correspondence throughout the year during which they hold office.

(8) Early in November copies of a printed form will be issued to Presidents of Sections for circulation to members of the Sectional Committees requesting them to nominate a President and a Recorder for the ensuing meeting for consideration by the Sectional Committee. Such proposals shall be accompanied by a statement of qualifications of the nominees for the office and their willingness to accept the same if elected thereto.

During the first week of December, the President of each Section shall circulate all such proposals received by him, together with the statements of qualifications, to the members of the Sectional Committee and request them to nominate by ballot one member for each office from among the list circulated, the ballot papers being received by him up to the 20th December.

At the first meeting of the Sectional Committee held on the opening day, the ballot papers shall be opened and scrutinized as the Chairman shall direct and the result communicated to the Executive Committee for consideration, together with a complete record of the Proceedings in this connection.

(9) The duties of the Sectional Correspondent and of the Local Sectional Secretary are given in Rules 30 and 32 (*c*).

(10) All persons entitled to be members of the Sectional Committee should enrol themselves without delay as Ordinary Members if not already so enrolled and should inform the General Secretary of the payment of their subscription when accepting the appointment.

(11) The General Secretary should be consulted whenever any question arises not dealt with in these regulations.

II. Local Arrangements.

In accordance with the Rules of the Association, the Local Secretaries and the Local Committee shall jointly, on behalf of and in consultation with the Executive Committee, make all necessary arrangements for the holding of the Session of the Congress.

The following arrangements have to be made:—

A. Accommodation for the Scientific Meetings.

(1) A large hall should be available for (*a*) the President's address on the opening day, and (*b*) for the evening lectures. Both (*a*) and (*b*) are open to the public free of charge. A projection lantern with an operator should be available in this room, and it is a great advantage if loud speakers can be installed.

(2) Rooms for the meetings of the different Sections of the Congress should be provided and suitably furnished. An epidiascope with an operator should be provided in each sectional room. All the rooms should as far as possible be in close proximity. The following are the Sections of the Congress:—

> Mathematics and Statistics, Physics, Chemistry, Geology and Geography, Botany, Zoology and Entomology, Anthropology and Archaeology, Medical and Veterinary Sciences, Agricultural Sciences, Physiology, Psychology and Educational Science, and Engineering and Metallurgy.

(3) A Reception room should be provided in which members can get information, write letters, etc. The Local Secretaries' Office should be as near as possible to this room. An arrangement should be made with the Postmaster-General to have a temporary Post Office in this room and for all letters addressed to members c/o The Indian Science Congress to be delivered here. The Indian Science Congress Post Office should be situated as near as possible to the Reception room.

(4) A room near the Reception room should be set apart for the General Secretaries' Office, which will be opened therein from the 31st December.

(5) Provision should be made for lunch in European and Indian styles at moderate charges near the Reception room.

B. Accommodation for Visiting Members.

The Local Secretaries should send out, not later than the end of November, a printed circular to all members enrolled, asking them if they desire that accommodation should be arranged for them. It is desirable, as far as possible, to provide private hospitality for the President, Sectional Presidents and Officers of the Congress. In this circular information should be given regarding the types of accommodation available, with the charges, and the nature of the climate during the Session. The Local Secretaries will receive periodically from the General Secretary list of members enrolled at headquarters.

C. Programme of the Meeting.

(1) (*a*) The Sections of the Congress meet daily in the morning generally from 9-30 A.M.

(*b*) Presidential Addresses of the Sections shall commence from 9-30 A.M.

(*c*) There should be no afternoon Presidential Addresses of the Sections.

(*d*) Symposia or joint discussions will be held either in the morning, or from 2 P.M.

(2) Public lectures are arranged by the Executive Committee, and are given at 6 P.M. or 6-30 P.M.

(3) A printed guide with a map of the locality in which the Congress is held should be prepared for distribution to members on the opening day. Only Ordinary, Honorary and Full Session Members are entitled to the Guide Book free of cost. A small charge not exceeding Re.1 (to be fixed by the Local Committee) may be made to other members desiring to have a copy. The Guide Book should contain a summary of information concerning the scientific and educational activities and a short history of the locality, in addition to general information likely to be of use to visitors.

(4) Arrangements should be made for giving due publicity to the activities of the Congress, both before and during the meeting.

(5) A list of members with their local addresses where known should be printed and distributed on the opening day. A supplementary list should be typed and posted in the Reception room and maintained up to date. The Local Secretaries shall arrange for this.

(6) A provisional programme of social engagements should be drawn up by the Local Secretaries and sent to the General Secretary by the 25th November. It is essential that this be sent in time, as it has to be printed and distributed with the abstracts by the first week in December.

The General Secretary will make arrangements for printing the programme drafted as above and distributing these to members enrolled at the time of the distribution of the abstracts.

The final programme shall be printed locally by the Local Committee in time for the opening of the Session.

D. General.

(1) Numbered badges for members of the Congress will be sent by the General Secretary to the Local Secretaries for distribution on the opening day of the meeting. The badges should bear numbers corresponding to the enrolment numbers. There should be additional badges for Officers.

(2) Members of the Local Reception Committee who have made substantial contributions to the funds of the Local Committee may be given complimentary tickets to attend the meetings.

(3) An audited copy of the accounts of the Local Committee should be sent to the General Secretary not later than the 30th April, following

the Session, for inclusion in the Proceedings of the Session. It is desirable that the Local Committee should contribute any surplus to the reserve fund of the Association.

(4) Twelve copies each of all local publications connected with the Congress (Guide Book, final programme, notices, cards, etc.) should be sent to the office of the Association for record at the conclusion of the meeting.

(5) Applications for membership will ordinarily be dealt with by the General Secretary at the Office of the Association up to the 15th December. After that date applications for membership will be forwarded to the Local Secretaries, who will open a separate account for the sale of membership tickets. The amount thus realized, together with unsold tickets, should be forwarded to the General Secretary immediately after the close of the Congress.

III. Financial.

(1) The accounts of the Association shall be audited once a year and the books closed on the 30th November each year for this purpose.

(2) The audited accounts shall be placed before the General Committee at the Annual Meeting with the observations, if any, of the Executive Committee.

(3) Sanction for all payments for amounts exceeding Rs.100 shall be obtained from the Finance Committee which shall consist of the General Secretaries, the Treasurer, and one Ordinary or Honorary Member resident in Calcutta who shall be nominated by the Executive Committee.

(4) Amounts received on account of Life Membership Subscription shall be credited to the Reserve Fund of the Association.

IV. Election by the Executive Committee.

(1) A letter shall be issued asking for nominations giving a last date therefor.

(2) The proposer should ascertain whether the person he proposes is desirous of serving in that particular capacity.

(3) After the nominations have been received the names should be circulated in a ballot paper and the date for return should be fixed two weeks after the ballot paper is sent out.

V. Nomination of General President.

(1) The General Secretary shall invite nominations for the office of General President of the Association, two years in advance, by a circular letter to the members of the Council, not later than the 15th of October. Such circular shall include a list of the General Presidents of the past 15 years, and the branches of science in which they had specialized.

Nominations shall reach the General Secretary not later than the 15th of November.

(2) The General Secretary shall circulate the nominations received to the members of the Executive Committee for expression of opinion on or before the 30th November. Such opinions shall reach the General Secretary not later than the 15th of December.

(3) The nominations, together with the views of members thereon, shall be placed for decision before a meeting of the Executive Committee to be held on the day previous to the commencement of the Session of the Congress.

(Adopted the 5th January, 1937. Revised the 8th January, 1939, the 6th January, 1940, the 6th January, 1941, the 5th January, 1942 and the 4th January, 1943.)

II. STATEMENTS OF ACCOUNTS.

I

Indian Science Congress Association.

Receipts and Payments Account for the year ending 30th November, 1942.

Receipts.

	Rs.	A.	P.	Rs.	A.	P.
To Balance as on 1st December, 1941:						
Reserve Fund Investments:						
4% Loan 1960/70 Face Value of Rs.10,000 at cost ..	11,416	10	0			
3½% G.P. Notes Face Value of Rs.1,000 at cost.. ..	945	3	0			
With Imperial Bank of India	420	15	0			
				12,782	12	0
With Imperial Bank of India, in Current A/c	2,470	1	8			
Imprest Cash (as certified) ..	115	0	0			
				2,585	1	8
,, Subscriptions:						
Ordinary and Session Members	10,593	0	0			
In Advance	36	0	0			
Additional Subscription, ..	290	0	0			
				10,919	0	0
,, Interest on Investments ..	....			226	6	0
,, Sale of Publications ..	....			462	10	6
,, Miscellaneous Receipts:						
Bank Charges	7	10	0			
Printing	306	14	2			
Postage	54	14	3			
				369	6	5
Total ..				27,345	4	7

Payments.

	Rs.	A.	P.	Rs.	A.	P.
By Printing	....			12,967	12	3
,, Postage and Telegram ..	....			1,826	5	9
,, Salaries	....			2,301	4	0
,, Travelling Expenses ..	....			507	1	9
,, Allowances	....			100	0	0
,, Audit Fees	....			50	0	0
,, Bank Charges	....			43	15	0
,, Contingency:						
Stationery	218	9	3			
Local Conveyance ..	29	1	0			
Badges	99	0	0			
Freight Charges ..	142	5	6			
Miscellaneous	36	0	3			
				525	0	0
,, Balances:						
Reserve Fund Investments:						
4% Loan 1960/70 Face Value of Rs.5,000 at cost ..	5,918	9	4			
3½% G.P. Notes Face Value of Rs.1,000 at cost ..	945	3	0			
				6,863	12	4
With Imperial Bank of India, in Current A/c ..	2,045	1	6			
Imprest Cash (as certified) ..	115	0	0			
				2,160	1	6
Total ..				27,345	4	7

Examined with the books and vouchers and found in accordance therewith subject to the following remarks:—

(i) That the sum of Rs.5,498-0-8 recovered from the Sale Proceeds of 4% Loan 1960/70 Face Value Rs.5,000 has been utilized for part payment of the outstanding bills from the Press. The printing expenses paid exceeds the provision made in the budget by Rs.4,967-12-3.

(ii) That the sum of Rs.646-4-0 being the balance interest on Investments has been transferred from Reserve Fund and included in the Current Account with Imperial Bank of India.

Ray & Ray,
Auditors,
Chartered Accountants.

6, *Church Lane,*
Calcutta, the 21st December, 1942.

J. N. Mukherjee.

INDIAN SCIENCE CONGRESS ASSOCIATION

THIRTIETH SESSION, CALCUTTA, 1943.

t of Receipts and Payments of the Local Reception Committee.

RECEIPTS.

	Rs.	A.	P.
To Donation:			
University of Calcutta	2,000	0	0
Others	3,029	0	0
,, *Indian Science Congress Association ..	250	0	0
,, Membership Fee	310	0	0
,, Sale Proceeds of Articles	78	0	0
TOTAL ..	5,667	0	0

PAYMENTS.

	Rs.	A.	P.
By Opening Ceremony and Meetings ..	727	7	6
,, Reception	25	2	0
,, Volunteers' Expenses	725	11	0
,, Printing	206	3	0
,, Establishment	213	1	6
,, Conveyance	74	2	6
,, Cost of Photographs	57	0	0
,, Postage and Telegrams	101	11	0
,, Stationery	137	5	3
,, Audit Fee	25	0	0
,, Telephone	50	0	0
,, Refreshment to Delegates	510	0	0
,, Indian Science Congress Association ..	560	0	0
,, Miscellaneous	56	8	9
,, Bank Charges	1	4	0
,, *Balance*:			
Cash at Bengal Central Bank, Ltd. on 13-4-1943	2,196	7	6†
TOTAL ..	5,667	0	0

(Sd.) P. BRAHMACHARI,
(Sd.) D. CHAKRAVARTI,
Local Secretaries,
Indian Science Congress Association.
(Sd.) P. C. MITTER,
Hony. Treasurer,
Local Reception Committee.
(Sd.) S. N. MUKHERJEE,
Jt. Hony. Treasurer,
Local Reception Committee.

Auditor's Report to the Members of the Local Reception Committee.

I have audited the above Statement of Receipts and Payments of the Local Reception Committee, Indian Science Congress, 30th Session, Calcutta, 1943, with the books and vouchers, and have obtained all the information and explanations I have required, and I certify the said account as correct and in accordance with the books of accounts.

10, Old Post Office Street,
Calcutta, the 13th April, 1943.

(Sd.) A. K. GHOSH,
Government Diplomaed Accountant,
Registered Accountant,
Auditor.

* Contribution by the Bengal Chemical and Pharmaceutical Works, Ltd. to the general funds of the Indian Science Congress Association.

† The Local Reception Committee has contributed the whole of its surplus amounting to Rs.2,195-7-6 (less the Bank of Re.1 on closing the account) to the reserve funds of the Indian Science Congress Association.

II. STATEMENTS OF ACCOUNTS

Proceedings of the Thirtieth Indian Science Congress

PART II—PRESIDENTIAL ADDRESSES

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ADDITIONS AND ALTERATIONS

in Mr. D. N. Wadia's Address on 'Minerals' Share in the War' on the next page.

Note: Mr. D. N. Wadia made certain additions and alterations in the original typescript during the delivery of his address. These were not incorporated in the proof from the Press. After printing of the Address, the mistake was found out.

Page 1.—Fifth line, after full stop (third sentence), *read* the following *in place of* 'The attendance of so many members......................country, provides gratifying' (up to end of seventh line):

'A membership of nearly 1,000 drawn from many fields of scientific activities and Government institutions from all parts of the country, and the attendance of even the few that have been able to gather here this morning, provide gratifying'.

,, Eleventh line, *add* 'in thirty years' *after* 'sixth time'.

,, Fifteenth line, *add* the following sentence *after* 'this session':

'It must have required no ordinary courage and organizing ability on the part of our general secretaries and the Reception Committee to undertake this responsibility during an emergency such as the present one.'

Page 2.—*Add* the following as second paragraph:

'On behalf of the delegates of the Congress I offer felicitations to Sir Jnan Chandra Ghosh on the honour of knighthood; to Rao Bahadur Vishwanath on the distinction of C.I.E. and Dr. W. R. Aykroyd for the title of O.B.E. conferred upon them by His Majesty.'

,, In paragraph 2, line 17, *omit* 'and conscientiously'.

Page 6.—In the second line, above the sub-heading, *add* 'own' *after* 'her'.

Presidential Address

(*Delivered on Jan. 2, 1943*)

Congress President:—D. N. Wadia, M.A., B.Sc., F.G.S., F.R.G.S., F.R.A.S.B., F.N.I.

MINERALS' SHARE IN THE WAR

The Indian Science Congress meets to-day for the fourth time since the beginning of the War. This meeting, only a few hundred miles remote from one potentially active war theatre, is an event which bears significant testimony to the place science has won in India. The attendance of so many members, drawn from many fields of scientific activities and Government institutions from almost all parts of the country, provides gratifying proof of their devotion to the cause of science and of their subscribing to its exacting ideals. Calcutta has once again made its contribution to the spread of science in India by inviting the Congress for the sixth time. We keenly appreciate the warm hospitality it has accorded us under conditions of difficulty we all realize and it is no mere formal expression of thanks that, in your name and on your behalf, I tender to the organizers of this session. A distinguished citizen of India was to have presided at this meeting and no one here shares, more keenly than I, in the disappointment at his absence to-day. I seek your forbearance at my having to address you because of an existing rule which requires your President of the foregoing year to continue in office until its assumption by his successor. Pandit Jawaharlal Nehru's contributions to science in India have not been in the limelight, but they have been a leavening influence in the organization and working of the National Planning Committee which, since 1939, is engaged in the great task of co-ordinating applied science with productive industry in every field—industrial, educational, cultural and organizational. Ladies and Gentlemen, please believe me, I sympathize with you for having missed his rousing address.

Death has removed from our midst during the year several distinguished workers in different fields of science. The Indian Science Congress mourns the deaths of: Rai Bahadur Ramaprasad Chanda, anthropologist, archaeologist and student of Indian art; Rai Bahadur Sarat Chandra Roy, Tibetan scholar, archaeologist and founder-editor of *Man in India*; Mr. Gauripati Chatterjee, meteorologist, distinguished for aerological researches in upper air; Dr. G. de P. Cotter, late of the Geological Survey of India and a past President of the Section of Geology; Colonel

Sir Francis Younghusband, reputed soldier, Central Asian explorer, geographer and a close student of Indian philosophy.

Reviewing the events of the year that has passed, the most outstanding and dominating event was the approach of the War to the doors of India. For the first time in the 4 millenniums of recorded Indian history, the enemy has assaulted the eastern frontiers of the country. By sea, land and air our 2,000 miles long eastern walls have been approached and threatened by the invading enemy. But equally significant in the annals of 1942 was India's answer to the invaders, the answer conveyed through its munitions factories, electric, chemical and the host of technical plants, industrial research laboratories and the hundreds of young University-trained men manning engineering, medical, naval and air corps during the year. This may truly be regarded as the greatest event of the last few years in the cultural life of the country—for the first time after her age-long belief in the force of philosophic and spiritual striving as the goal of life, India has taken up the challenge of science and the machine and is adjusting itself intelligently and conscientiously and with surprising quickness, to compose a society in which strivings for both material and spiritual well-being are equally regarded as ruling factors in a perfect life. That indeed is an ideal difficult to achieve for any people, but in present-day India the changeover is taking place at a remarkably accelerating pace. Indian scientists by their last 30 years' work in different branches of science have made a notable contribution towards fostering the new mental attitude which has brought about this difficult welding. H.E. Lord Linlithgow happily expressed the need of such welding for the people both of the East as well as the West in his opening address before the Jubilee Session of the Indian Science Congress held in Calcutta in 1938. 'Even the most enthusiastic believer in Western civilization must feel to-day a certain despondency at the present failure of the West to dominate its scientific discoveries and to evolve a form of society in which the material progress and spiritual freedom march comfortably together. Perhaps the West will find in India's more general emphasis on simplicity and the ultimate spirituality of things, a more positive example of the truths which the most advanced thinkers of the world are now discovering.' To this consummation philosophy and science must aim if the one is not to end in ultimate futility after ages of persistent effort and the other not to achieve, as a reward of its magnificent discoveries and inventions and its conquests over Nature, a barren desert of frustration through a succession of world wars.

Minerals' Share in War.

A geologist's work during wartime is largely mobilizing all mineral resources in his own limited sphere for munitions

purposes. Free international movement of minerals having ceased, every country has to produce the full quota from its domestic mineral resources. Far-reaching questions will arise in the near future, if indeed some have not already arisen, as to how long minerals from accessible depths of the earth will be able to sustain man's wars.

Man's advancement to civilization from the hunter and peasant stage is due to his mastery over metals and minerals, but this advance has caused most serious inroads on the world's stock of minerals and especially of metals. During the century and quarter between the Napoleonic wars and the Hitlerian war, the consumption of minerals has been over a hundred-fold of that consumed during the entire history of man on earth and so far as metals are concerned, man has used up between 1914 and to-day, between the two German wars, more metals than during any previous period of history. Metals such as tin have almost reached depletion stage, silver is being made to stand substitute for tin, while the extractable stock of platinum, silver and gold left for future needs of the world within manageable depth will be very meagre. The consumption of fossil fuels, coal and petroleum has been at a far more serious rate, so serious that the world's known reserves of mineral oil at the present rate of production will be exhausted in a few decades. The total world coal reserves are larger, but they will last only a few decades longer, if the present acceleration of production and consumption of coal and its use for the ever-lengthening catalogue of by-products continues in the future at the same rate. So far no checks have been devised for this alarming depletion of the world's underground wealth,—this robbing of the earth by the living generation at the expense of future generations. Metals and minerals are a rapidly wasting asset of a country for which there is no renewal or replacement. Agricultural and forest resources of a land can be rejuvenated by suitable measures and manures, but no fertilizer can revive one exhausted mine, for geological processes are exceedingly slow requiring hundreds of thousands of years to form a vein of metallic ore or a bed of coal.

There are some 1,500 distinct species of minerals known; of these about 200 find application in commerce and industry and are considered economic minerals. Among these again there is a rapidly mounting list of metals and minerals which are of vital use in the manufacture of munitions of war and of highly specialized commodities of strategic use. In the defence programme of a nation under the present-day conditions of totalitarian warfare, the metallurgical industry and its ancillary mining of minerals yielding the ferrous and alloy metals, fluxes, refractories and accessory minerals are of essential importance. A significant feature of the distribution of these minerals is the concentration of their production and manufacture in a comparatively few countries in the world, happily nearly three-fourths

of these being centred in, or controlled by, the United Nations as against the Axis group. Of the total annual mineral production of the world in pre-war years, as much as 85% came from North America and Western Europe, of these U.S.A., England and Germany and latterly Russia contributing over 75%. This, however, does not mean that Nature has endowed these countries to this unequal extent with valuable minerals, it rather is an index of the country's industrial and technical development and the energy of the people. Russia's three successive five-year plans are an example of this. Industrial progress of other parts of the world may materially change this condition. For instance, China's vast reserves of coal, hitherto untapped for lack of economic employment may, in the not distant future, be put to use in metallurgy, or in the production of heat energy or other profitable channels. India's resources in iron-ore are of a magnitude quite out of proportion to the bare couple of million tons of pig iron per year it has only recently begun to produce. Only in a few districts of Bihar and Eastern States Agency, the high-grade iron-ore reserves are calculated to be of the order of 4,000 million tons. Large reserves of aluminium-ore are still only potential assets. The minerals of South America and Africa are yet in an early stage of development, while Australia's store of mineral wealth is yet unknown over wide tracts of that region. When these untouched reserves enter production stage, the apparent inequalities will diminish and the countries bordering the North Atlantic basin will not occupy the dominating position in strategic minerals they do at present.

But even so, when the whole world's mineral resources are fully known and mobilized, the stock will not last many generations, if it is made to feed the waste of recurring wars on the scale of magnitude and frequency of the last two world wars. If the supply and free movement of a few ferro-alloys and a few strategic key minerals for non-industrial uses is controlled by some central world organization, the demon of totalitarian war can be banished and the remaining wars shorn off their insane waste involved in military as well as non-military devastations. Then the wreckage of tanks and armour-plates can be beaten back into ploughshares and its superior steel released for beneficent uses in peace.

It is no exaggeration to say that half of the later wars of history have been directly or indirectly motivated through the desire of gaining access to stores of strategic mineral products, ores, fuels, salts, alloy metals and essential industrial minerals.

The international mineral situation during pre-war years was in a chaotic state. While the United Nations were in a state of 'vacuous unwareness' about it, the Axis powers grabbed as much of the indispensable munitions minerals as they wanted and the war has been waged by them on the stores of hoarded minerals and metals.

Only the adoption of a wise and justly planned international mineral policy framed by an International Directorate can preserve peace and good-will amongst countries unequally endowed by Nature with mineral wealth. No country in the world, however well-supplied it be, is self-sufficient in mineral requirements, nor is any so situated that it can regard its mineral resources as purely domestic or national. Embargoes, tariffs, patent rights and transport controls imposed for political reasons do not offer a solution, but by hindering free movement of minerals they become powerful contributive factors in precipitating world wars. Unequal geographical distribution of minerals being an unalterable fact, planned international economy should devise means not only to eliminate this cause of inter-country friction but to increase the interdependence of nations on each other for their vital trades and industrial needs and so make minerals a rallying point for international co-operation and good-will. The preliminary recommendations of the Conference on 'Mineral Resources and the Atlantic Charter', convened by the *British Association's* Committee on Social and International Relations of Science last July, appear to be on the right lines, but they will not go far enough if their implications are meant to safeguard the interests of the British Empire only, or even of the whole United Nations' group. These should embrace all the free countries and should call for sacrifice from all participating nations of part of their national and natural advantages for the ultimate benefit of all and the future security of the peoples of the world. The main resolution of this Conference reads as follows:—

> 'This Conference, having specifically dealt with mineral resources, submits that, as a first step, the Council should initiate forthwith consultations with appropriate scientific and technical organizations, to secure an understanding on the principles involved. The Conference would further urge that a scientific review of mineral resources, using and supplementing all existing data, should be among the first tasks of any international organization for the social applications of science, such as was envisaged at the recent Conference on Science and World Order. To this end, the Conference recommends that the Council should consider how it might help to promote the establishment of an International Resources Organization, as a fact-finding and advisory body for Governments, as a contribution to world stability, and in the spirit of the Atlantic Charter.'

The fourth article of the Atlantic Charter postulates access for all States on equal terms to the raw materials of the world. But if the Atlantic Charter does not unreservedly provide for all peace-loving nations of the earth, whatever oceans bound

them, its fulfilment in a partial degree will not achieve the goal of post-war mineral allocation, nor succeed in removing a focal infection point in the body politic of the world.

The position of mineral affairs to-day being what it is, it behoves us as non-Utopian science workers to ask—What is India's place in the world's mineral map? The mineral outlook of the Indian region is on the whole satisfactory both for war and peace-time requirements. India's resources in minerals of strategic importance, minerals for munitions and defence armaments, base metals, alloys, fluxes, refractories and accessory minerals can be regarded as adequate, in several but not all of them. India is deficient in tin, tungsten, lead, zinc, nickel, graphite and liquid fuels. But in the basic metals, iron, manganese, aluminium and chromium, the country is well supplied, in the case of the former three, in large excess. Our neighbour, Burma, has abundant stocks of the munition metals of which India is in defect, while her oil resources must yet be regarded as considerable. Ceylon has reserves of the world's finest graphite, a mineral indispensable in metallurgy and of a magnitude sufficient to last a long period. Ancillary minerals such as asbestos, cement, fertilizers, clays, mica, sulphur, various salts, ores and other minerals of industrial utility are available in quantities sufficient for the country's needs, while some are in exportable surpluses.

The experience of the last three years' war effort in the production in India of a wide range of munitions, without any previous apprenticeship, is satisfactory proof of the country's adequacy in some respects, though still unequipped in a number of essentials, viz. specialized steels, machine tools, manufacture of aircraft, high explosives, automobile engines, big ship construction, etc. on a scale commensurate with her internal requirements.

The Social Obligations and Relations of Science in India.

Last year, while addressing you on the progress of the exact sciences in India during the last 30 years, I stated that the retrospect was satisfying and held out promise of further developments. The time, however, has come, and the events of the last few years forcibly remind us of the fact that science, as pursued in the laboratory and the field, is becoming more and more a specialist's job and is becoming divorced from the life of the people. Science, as applied to the problem of daily living and the social needs of the common man, is the great necessity of the day. The advent of the motor bus, the radio and the railway engine in the villages of India is not the same thing as bringing science to the homes of our villagers. The impact of science on the Indian masses has come in the form of a rather rude intrusion of machines and mechanics into the essentially simple rural

economy of the country and it is not surprising that this meeting has not been a particularly happy one. It has disturbed the economic structure and created, if not some aversion, an indifference to the cult of science in the popular mind. But we all know that science is not all mechanics nor are its practical uses to man the greatest thing about science. The greatest thing about science is the scientific method—the most effective thing man has for discovering truth and the ways of Nature. It can bring solid benefits by releasing life from stagnation and the bonds of ignorance wherever these prevail, whether in cities or in the country-side, among the labouring masses or among the governing class. The awakening to the social obligations of science is of recent date and even in Europe and America, this aspect of the cultivation of science was for long not realized and left to sporadic individual efforts. With this awakening, a two-fold problem faces science all over the world to-day—to press the newest discoveries and inventions of applied science into the service of agriculture, manufactories, hospitals, homes and schools, and alongside with it to so control the impact of these on his private life that his mechanized work-a-day life may not be totally divested of all higher spiritual values. Our future national life and its material well-being largely depend on a wholesome balance being maintained between these two—the impulse to harness science to increase physical comforts of life and a restraining desire to preserve the old-world spiritual calm and simplicity of living. Happily for India, this balancing is somewhat of a natural hereditary trait and does not need much emphasis. While in the European countries the evolving of a true synthesis, a *via media*, demands much searching and learned arguing, our age-old traditions have made this work easier. India's late start in the application of science to industry also gives it an opportunity of planning along right lines. The significance of this problem has been realized by both our political leaders as well as scientists, and some progress is made in this direction. I refer to the inauguration in 1939 of the National Planning Committee under the chairmanship of Pandit Jawaharlal Nehru, with the specific object of co-ordinating science with industry in all its phases, and to the establishment by the Indian Science Congress at its Lahore session in January, 1939, of a sub-committee on Science and Social Relations, mainly with the object of studying the influence of science on India and collecting data relating to the effects of science on society in India.

The National Planning Committee, through its 29 sub-committees, has set out on formulating a programme covering many phases of the country's future life and activities, material, productive, educational, artistic. Their work unfortunately is in a great measure suspended to-day, though some of the 29 sub-committees have furnished more or less complete, well-

documented reports, while others have submitted interim fact-finding reports. Their conclusions, doubtless, will be subjected to thorough revision and deliberation by the main body which comprises 200 of the leading industrialists, publicists and scientists of the country, before they are offered to the public, but a great deal of spade work is accomplished, a valuable mass of ascertained classified details collected and many blue-prints prepared. A planned reconstruction in a greater or less measure of India's commerce, industry, finance, land, labour, mining, transport, power-generation, technology alongside educational, cultural and social re-organization is expected to emerge from the labours of this body.

Proposed Academy of Social Science for India.

The Executive Committee of the Indian Science Congress has before it a proposal for the institution of a National Academy of Social Sciences drawn up by the sub-committee on Science and Social Relations. It is interesting to trace the origin of this sub-committee which goes back to the Blackpool meeting of the British Association for the Advancement of Science in 1936, which meeting was devoted to the discussion of the Social Relations of Science. In the following year, a few leading Science Associations took cognizance of this subject. The International Council of Scientific Unions with its headquarters at Delft, Holland, at its meeting held in April, 1937, in London, established a Committee on Science and Social Relations with Professor F. G. M. Stratton, of Cambridge University, as President. This action of European scientists was followed by a resolution passed by the American Association for the Advancement of Science at its meeting in 1937 urging the various scientific organizations of the world to re-undertake examination of the profound charges brought about by science in human society and thus to be in a position to promote 'peace among nations and intellectual freedom in order that science may continue to advance and spread more abundantly its benefits to all mankind'. In 1938 the British Association at its meeting held at Cambridge brought into being a special Division for Social and International Relations of Science with Sir Richard Gregory as its Chairman. This division organized a Conference on 'Science and the New World Order' in London during September, 1941. In conjunction with these sister organizations of Europe and America, the Indian Science Congress instituted a sub-committee on Science and Social Relations at its annual session held in Lahore in January, 1939. This sub-committee has been working for the last three years and its labours have fructified in the above proposal which in due course will come before the Indian scientists and to which they will have to give their most careful consideration.

The proposed Academy should be a body of high academic standing and professional knowledge, which can take up long range problems of social well-being of the people of India which the older Societies and Associations, established along familiar but too general lines in some cases and rather over-specialized lines in others, cannot deal with without suspicion of religious or political bias. Socio-medical and political subjects, human relations, anthropology, political science, vital statistics, social biology, population problems, sociological research in particular bearing on various Indian communities are the subjects on which such an Academy can work in collaboration with the Indian Science Congress and half a dozen other institutions already existing in the country for some of the above-named specific objects. It can be a living organ in the body politic of India for voicing the collective opinion and focussing the specialized points of view of numerous isolated working bodies on the one problem, how to promote the well-being of the common man. The sub-committee has begun a survey of the status of sociological studies in all the Indian Universities. Vice-Chancellors of many Indian Universities have endorsed the proposal about the Academy favourably, and the secretaries of those learned societies that have been approached have announced their readiness to co-operate. Dr. K. Motwani, the Secretary of the sub-committee, personally placed the scheme before Pandit Nehru last July and, in accordance with Pandit Nehru's wishes, the Executive Committee proposes to appoint a Committee of Experts to suggest ways and means of bringing this Academy of Social Sciences into being. The matter rests here. It is too early to outline the exact task to which the Academy will address itself. Its chief function will be to explore those avenues through which the contributions of science may be adapted to the life of the individual and the nation without allowing any anti-social applications of science such as have made a shambles of so many countries, ever raising their heads in our midst. Secondly, the Academy should emphasize an integrated, synthetic approach to every problem, pressing into service the contributions of various basic social sciences, such as human geography, anthropology, psychology, economics, political science, philosophy and sociology. The bringing into being of a National Academy so constituted may well become a crowning achievement of the Indian Science Congress.

SECTION OF MATHEMATICS AND STATISTICS

President :—S. C. DHAR, D.Sc. (CAL. & EDIN.), F.R.S.E., F.N.I.

Presidential Address

(*Delivered on Jan. 3, 1943*)

CERTAIN DEVELOPMENTS OF MATHEMATICS IN THE LAST THIRTY YEARS

(*Operational Calculus and Automorphic Functions*)

INTRODUCTION

At the outset allow me to express my sincerest thanks for the honour you have done me by electing me to preside over the deliberations of this section of the Indian Science Congress. It is an honour which I greatly appreciate.

In my address I would like to put before you some particular aspects of the development of mathematics during the last thirty years. The development of mathematics and new technique, that was forged to tackle problems of Nature, are so varied and diverse that it is very difficult for a single mathematician to cope with the assimilation of the advancing knowledge, much less to think of actively participating in all its various ramifications. I have therefore been obliged to talk to you to-day on subjects in which I myself was interested during the last few years. I shall concentrate on only *two* important aspects of the mathematical development of this century—one in which the mathematical physicists and electrical engineers as well as pure mathematicians are interested and the other is mainly the concern of the pure mathematicians. These are—THE OPERATIONAL OR SYMBOLIC CALCULUS and the AUTOMORPHIC FUNCTIONS. The importance of these subjects was drawn attention to by no less a mathematician than Prof. E. T. Whittaker, F.R.S., who writing about Heaviside [1] says:—

'We should now place the *Operational Calculus* with Poincare's discovery of *Automorphic Functions* and Recci's discovery of the *Tensor Calculus* as the three most important mathematical advances of the last quarter of the nineteenth century. Application, extension and justification of it constitute a considerable part of the mathematical activities of to-day.'

I. Operational Calculus

Historical Background.—The rôle that mathematics has played in the last 150 years is firstly to devise various methods to tackle problems that presented themselves for solution. While, on the one hand, the development of physical sciences presented various problems for the mathematicians' ingenuity, mathematicians themselves, on the other hand, forged methods in the shape of new branches of mathematics which the physicists took advantage of in unravelling the mysteries of Nature. An instance of the first is the *Fourier's Analysis* developed for solving the problems of the conduction of heat in an isotropic solid. This new technique was stimulated by the necessity of solving the physical problem. Another example of this in recent years is the *Operational Calculus.* As instances of the second category one may mention the *Recci* or *Tensor Calculus*, *Matrix Analysis*, the *Group Theory* and so forth which were highly developed by the mathematicians long before the physicists thought of ever using them for solving their own problems. In the language of Dirac [2] one may describe the situation by saying 'the mathematician plays a game in which he himself invents rules whilst the physicists play a game in which the rules are provided by Nature but as time goes on it becomes increasingly evident that the rules which the mathematicians find are the same as those which Nature has chosen'.

Another aspect of the development I should not miss is the reaction which the new technique had on pure mathematicians. It gave stimulus for investigation which also enriched pure mathematics. The great controversies that were raised by Fourier's analysis are well known to all students of mathematics. Some of the leading mathematicians of the time like Laplace refused to recognize it as a legitimate method in mathematics. The controversies raised were fortunately instrumental in the advancement of rigorous mathematics. In fact, Fourier's work was the starting point in which the development of many of the modern theories of functions of real and complex variables may be supposed to have its origin. The contributions made to the theory by Dedekind, Cantor, Weierstrass, Dirichlet, Cauchy, Riemann, Du Bois Reymond and many others helped towards building up of the general theory of functions in pure mathematics.

Now coming to the subject of my discourse—the *Operational Calculus*—I find history is repeating itself. The method which Heaviside introduced in the solutions of transient electrical problems met with utmost opposition from pure mathematicians, especially of the Cambridge school, who refused to recognize it as a legitimate method in the solutions of differential equations of mathematical physics. At that time the most influential amongst them in England were trying to raise the standard of

rigour which the German mathematicians had adopted under the influence of Weierstrass and so naturally his process was regarded as a kind of mathematical *blasphemy*, in the words of Whittaker. It was reserved for the two mathematicians, Bromwich [3] and Wagner [4], who independently laid the basis of rigorous foundation of Heaviside [5] operational calculus. In a memorable paper published in the *Proceedings* of the London Mathematical Society while establishing the validity of Heaviside expansion theorems, Bromwich writes, 'It is almost certain that few readers have fully grasped the complete and general character of the solution.' On another occasion he writes [6], 'It may also be of interest to refer to a conversation with Prof. G. H. Hardy some time before 1914 in which he expressed the view that what analysis then needed was a *twentieth century Euler* capable of trying daring experiments with what one might call "conjuring tricks in Mathematics", the details of justification might then be filled in by workers at their leisure. Probably Prof. Hardy regarded his later discovery of Ramanujam as having filled that rôle to some extent, at any rate in one region of analytical development, but I venture to suggest that at least in his own domain Heaviside was certainly a *twentieth century Euler.*'

Truly Heaviside performed daring experiments with analysis which brought on his head the criticism or, should I say, persecution from the 'scienticulists' and 'mathematicians' of Cambridge of conservative kind 'who took the gift-horse in the mouth'. Like Ramanujam before he joined Cambridge, Heaviside had little training in mathematics to justify his analysis. It was reserved for others to justify it and now it is admitted on all hands that Heaviside operational methods represent a distinct and epoch-making advance of the mathematical knowledge of the century.

I have taken long in justification of his work but my only excuse is that there are still some amongst us who are sceptical about his methods.

Operation and Heaviside's Method.—The idea of 'operator' and 'operation' is of recent growth, but traces of its use will be found in the works of Boole, Greaves and Murphy. In the solution of linear differential equations with constant coefficient, the particular solution is expressed in the form

$$y = \frac{1}{f(D)} \cdot T, \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where $D = \dfrac{d}{dt}$ and the solution is obtained by regarding D as an algebraical quantity, expanding $1/f(D)$ in powers of D and interpreting the result and then adding to it complementary function. If the initial conditions, i.e. the values of $y, y', y'', \ldots$ etc. are given, then the values of the arbitrary constants have

to be found out by solving n simultaneous equations, n being the order of the differential equations.

Heaviside's [5] main contribution to the operational method in the solution of differential equation consists in:—

(i) substitution of p for $\frac{d}{dt}$;

(ii) incorporation of initial conditions prior to the final solution, i.e. what we shall call 'getting the subsidiary equation';

(iii) expansion in inverse powers of p, or what now may be called the 'algebraization' of differential equations;

(iv) expansion in ascending fractional powers of p to obtain asymptotic expansion; and

(v) finally, interpretation of the expansion by the relation

$$p^{-\nu} \doteqdot \frac{t^{\nu}}{\Gamma(1+\nu)} \quad (\nu > -1). \quad .. \quad .. \quad (2)$$

By these means he solved many transient problems in cable telegraphy and telephony and got correct results. He was, however, unable to justify his processes.

Discrete Systems.—This method is easily applicable to discrete motion given by the n simultaneous differential equations

$$e_{rs}x_s = S_r, \quad (s = 1, 2, \ldots . n) \quad .. \quad .. \quad (3)$$

using the notation of tensor calculus, where $e_{rs} = a_{rs}\frac{d}{dt} + b_{rs}$, a_{rs} and b_{rs} being constants. If $u_1, u_2, \ldots .$ are the values of $x_1, x_2, \ldots .$ where $t = 0$, then writing p for $\frac{d}{dt}$, Heaviside forms the n subsidiary equations

$$(a_{rs}p + b_{rs})x_s = a_{rs}pu_s + S_r. \quad .. \quad .. \quad (4)$$

Regarding p as an algebraical quantity, these equations can be solved algebraically and the solutions are

$$x_m = \frac{E_{rm}}{\Delta}(pa_{rs}u_s + S_r), \quad (m = 1, 2, \ldots . n), \quad .. \quad (5)$$

when $\Delta \equiv \text{det.}\ (e_{11}, e_{22}, \ldots . e_{nn})$ and E_{rm} is the minor of e_{rm} of Δ. If we assume that det. $(a_{11}, a_{22} \ldots . e_{nn}) \neq 0$, then Δ is of degree n in p and E_{rm} is at most of $(n-1)$ degree. The operation E_{rm}/Δ can be expanded in negative powers of p, the positive powers of p not occurring at all.

So far as the term $E_{rm}\ pa_{rs}u_s/\Delta$, it can be interpreted by (2); but S_r is generally a function of time. In order to interpret the second term of (5), Heaviside uses a unit function $H(t)$ such that

$$\left.\begin{aligned} H(t) &= 1, \quad t \geqslant 0 \\ &= 0, \quad t < 0 \end{aligned}\right\} \quad .. \quad .. \quad .. \quad (6)$$

If then $f(t)$ be a regular function, it can be expressed in the form

$$f(t) = -\int_{h=-\infty}^{\infty} f(h)d[e^{-ph}H(t)], \quad \ldots \quad \ldots \quad (7)$$

an integral of the Steiltjes type.[7]

The function under the d-sign is discontinuous at $h = t$; but we can in many cases integrate with regard to h, regarding p as an algebraical quantity and thus obtain a function of p operating on $H(t)$, in the form

$$f(t) = g(p) \,.\, H(t). \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

This device simplifies evaluation of the result of an operation on a function and replaces decomposition into trigonometrical or exponential forms; for if the solution of the part of (5) with S_r, where $S_r \equiv f(t)$ be $\phi(p)\,.\,f(t)$, then we can get $\phi(p)g(p)\,.\,H(t)$ and then interpret the result.

In problems of mathematical physics S's are generally constants or of exponential forms, so little difficulty occurs in evaluation.

Second Order Differential Equations of the Discrete Systems.—The above method was applied to a set of second order equations

$$e_{rs}x_s = S_r, \quad (s = 1, 2 \ldots . n). \quad \ldots \quad \ldots \quad (9)$$

where $e_{rs} = a_{rs}\dfrac{d^2}{dt^2} + b_{rs}\dfrac{d}{dt} + c_{rs}$ and where in the ordinary dynamical interpretation, the coefficients a_{rs} are those of the kinetic energy, b_{rs} those of the dissipative forces, c_{rs} those of the potential energy and S_r are the impressed forces which may naturally be functions of time [8].

H. Jeffreys[9], however, gives a method in which he introduces n new variables $y_1, y_2, \ldots . y_n$ given by

$$\frac{dx_s}{dt} - y_s = 0 \quad \ldots \quad \ldots \quad \ldots \quad (10)$$

and then gets the equations (9) of the first order,

$$a_{rs}\frac{dy_s}{dt} + (b_{rs}y_s + c_{rs}x_s) = S_r. \quad \ldots \quad \ldots \quad (11)$$

From (10) and (11) he writes down the subsidiary equations representing the given initial conditions and writes p for $\dfrac{d}{dt}$. Thus there are $2n$ simultaneous equations involving $2n$ variables which can be solved by ordinary algebra and the solution in x's can then be interpreted.

Heaviside Operators—non-commutative.—Heaviside started with the operator p and recognized only the inverse powers of

p. The meaning of p is called for, as it is not possible to express p as inverse powers of itself. We observe that if $Q \, . \, y = \int_0^t y\,dt$ then

$$\frac{d}{dt} \cdot Q \, . \, f(t) = f(t), \qquad \ldots \qquad \ldots \qquad \ldots \qquad (12)$$

$$Q \cdot \frac{d}{dt} f(t) = f(t) - f(0). \qquad \ldots \qquad \ldots \qquad (13)$$

Thus Q and $\frac{d}{dt}$, i.e. p, are non-commutative [10]; but, if $f(0) = 0$, then they are commutative. It also provides an interpretation of p, viz. it is the inverse of Q and in any operation *it should follow* Q, unless the function operated upon vanishes at $t = 0$.

This is also true when we consider the partial fraction rule of Heaviside. Thus we can regard $\frac{1}{\alpha} \frac{p}{p-\alpha} \cdot 1$ as either $\frac{1}{\alpha} \cdot \frac{1}{p-\alpha} \cdot p \cdot 1$ or $\frac{1}{\alpha} \cdot p \cdot \frac{1}{p-\alpha} \cdot 1$. Now

$$\frac{1}{\alpha} \cdot \frac{1}{p-\alpha} \cdot p \, . \, 1 = \frac{1}{\alpha} \cdot \frac{1}{p-1} \, . \, 0 = 0 \qquad \ldots \qquad \ldots \qquad (14)$$

$$\frac{1}{\alpha} \cdot p \cdot \frac{1}{p-\alpha} \cdot 1 = \frac{1}{\alpha} \cdot p \left[\frac{1}{\alpha} \left(e^{\alpha t} - 1 \right) \right] = \frac{1}{\alpha} e^{\alpha t}. \quad \ldots \qquad (15)$$

Thus p and $\frac{1}{p-\alpha}$ are non-commutative and we remember the rule that the *direct operation should follow the inverse operation* in any expression when both occur.

Another operator used by Heaviside is e^{hp}. Here we find

$$e^{hp} \, . \, Q \, . f(t) = \int_0^{t+h} f(t)\,dt \qquad \ldots \qquad \ldots \qquad (16)$$

$$Q \, . \, e^{hp} \, . f(t) = \int_h^{t+h} f(t)\,dt. \qquad \ldots \qquad \ldots \qquad (17)$$

Here also e^{hp} and Q are non-commutative and we should stick to the above convention that the direct operation e^{hp} should follow the inverse one Q, unless h is negative. Heaviside, however, always used e^{hp} when $h < 0$ and hence he got correct result.

Most of the fruitful sources of error is due to non-observance of this convention of operators when interpreting the results.

Complex Theory for the Solution of Differential Equations.—The method of solving differential equations by complex integrals was first given by Cauchy but it was Bromwich [3] who modified it

so that the arbitrary constants in the solution were directly and immediately expressed in terms of the initial conditions. He applied his method to solve the problem of discrete motion having n degrees of freedom subject to initial disturbances.

Let the motion be given by the simultaneous equations given in (3). Bromwich substitutes for x, the contour integrals

$$x_r = \frac{1}{2\pi i} \cdot \int e^{\lambda t} \xi_r \, d\lambda,$$

where $\xi_1, \xi_2, \ldots . \xi_n$ are certain functions of λ to be found satisfying the initial conditions of motion and the integration is to take place along closed path in the λ-plane enclosing the poles of the function ξ_r, which may in many cases be reduced to *Bromwich path*, *Br*, keeping all the singularities of the function to the left. He has further shown that Heaviside's interpretation of (5) by partial-fraction-rule is the same as that given by his method. If (5) be expressed in the form

$$x_m = \phi(p) \,.\, 1 \text{ or } \phi(p) \,.\, H(t),$$

then the interpretation by Bromwich method is given by

$$\phi(p) \,.\, 1 = \frac{1}{2\pi i} \int_C \frac{e^{\lambda t}}{\lambda} \phi(\lambda) d\lambda, \quad \ldots \quad \ldots \quad (18)$$

$$\phi(p) \,.\, H(t) = \frac{1}{2\pi i} \int_{Br} \frac{e^{\lambda t}}{\lambda} \phi(\lambda) d\lambda. \quad \ldots \quad \ldots \quad (19)$$

In the former C is a contour which may be a large circle in the complex plane enclosing all the singularities of the integrand and *Br* is the Bromwich path from $c-i\infty$ to $c+i\infty$, $c>0$, c being such that all the singularities of the integrand are to the left of the path. Thus the solution (5) can be interpreted by complex integration given in (19) and we find that the result thus obtained is the same as can be got by Heaviside *Partial Fraction Rule*. Thus Bromwich removed the doubts of the pure mathematicians and since then the operational methods gained general acceptance.

Wagner [11] also studied the problem independently at the same time and got some of the results of Bromwich. Hence we shall call either of the integral (18) or (19) *Bromwich-Wagner integral*.

Fractional Differentiation and Integration.—Fractional differentiation and integration play a great part in the operational calculus. Fractional differentiation was first used by Liouville. Also in the work of Riemann [12] we find the use of fractional differentiation and integration, a report of which is to be also found in Pincherle's article [13] in the German Encyclopaedia.

Not much notice was taken of the idea of fractional differentiation and integration until Heaviside's time, who was himself unfamiliar with the works of Liouville and Riemann, but who used it frequently in his solutions of transient electrical problems.

By Bromwich-Wagner integral it is easy to find the results of fractional differentiation and integration. We note the following results constantly employed in the operational calculus:—

$$p^n \,.\, H(t) = \frac{t^{-n}}{\Gamma(1-n)}, \text{ (except when } n \text{ is a positive integer)}, \quad \ldots \quad (20)$$

$$\left.\begin{aligned} e^{-aq} \,.\, H(t) &= 1 - erf \,.\, \frac{a}{2\sqrt{2}}, \\ \text{where} \quad erf \,.\, \omega &= \frac{2}{\sqrt{\pi}} \int_0^{\omega} e^{-t^2} dt. \end{aligned}\right\} \quad \ldots \quad \ldots \quad \ldots \quad (21)$$

Carson's Investigations.—After Bromwich, Carson[14] studied the operational solution by the help of integral equation. He shows that if $f(t)$ is the operational solution of $\phi(p) \,.\, H(t)$, or of $\phi(p) \,.\, 1$ as given by

$$\phi(p) \,.\, H(t) = f(t), \quad \ldots \quad \ldots \quad \ldots \quad (22)$$

then the function $f(t)$ is given as the solution of the integral equation

$$\phi(p) = p \int_0^{\infty} e^{-px} f(x)\, dx. \quad \ldots \quad \ldots \quad (23)$$

This relation can be looked at from another point of view. Thus, on the one hand, when the function $f(x)$ is known, its operational representation $\phi(p)$ is found by integration; on the other hand, when the operational representation $\phi(p)$ of an unknown function $f(t)$ is given, then $f(x)$ is given as the solution of an integral equation (23) which can be solved.

The integral (23) is called *Carson's integral* and is Laplacian transformation. When $\phi(p)$ is known, then *Mellin-Fourier theorem*[15] will give $f(x)$ by means of the Bromwich-Wagner integral

$$f(x) = \frac{1}{2\pi i} \int_{c-i\infty}^{c+i\infty} \frac{\phi(p)}{p} e^{px} dp \quad \ldots \quad \ldots \quad (24)$$

when $c > 0$, and all the singularities of $f(p)$ lie to the left of the path of integration.

As we shall see later on, Van der Pol[16] calls $\phi(p)$ the image of the 'original' $f(t)$ and denotes it by the symbolic notation

$$\phi(p) \doteqdot f(t). \quad \ldots \quad \ldots \quad \ldots \quad (25)$$

Thus when $f(t)$ is given, its operational representation will be given by the Carson's integral (23) and when $\phi(p)$ is known, then $f(t)$ will be known from (24), the Bromwich-Wagner integral. Levy and March[17] have proved that when $\phi(p)$ is given, there is one and only one function $f(t)$ which is its original and we see that when $f(t)$ is known from (23), we can obtain one and only one value of $\phi(p)$, its operational representation.

Now from the definition of the operational representation of $\phi(p)$ of a function $f(t)$ by the Carson's integral, a set of theorems[18] has been derived by him which are of utmost importance in the operational calculus and in the solutions of electrical and other problems.

Continuous Systems.—The general impression that we form of the universe is that every phenomenon represents a continuous system and all its laws therefore partake of the continuity. It is this quality which the physicists and the mathematicians have taken advantage of in expressing the action of Nature by laws. There seems to be some mathematical quality in Nature which plays an important part in its workings. In fact, Nature is a Mathematician who chooses to express Himself to its votaries in the form of ***differential equations.***

Now in the complete description of the universe we not only require a complete system of differential equations of motion either according to the mechanistic scheme of physics or to its relativistic modifications, but a complete system of initial conditions is necessary. So every phenomenon of the continuous system is expressible as partial differential equations with a certain necessary number of initial and boundary conditions. The former is the result of mathematical theories, but the latter can only be determined by observations and are not amenable to theories. Thus says Dirac, 'It would have been possible to foretell the fate of the universe according to the mechanistic scheme, if we could have known the initial circumstances of its motion'. But the mathematicians' business is to develop a technique for the solution of such differential equations when the initial conditions are known.

Such a technique for solving the partial differential equations of the continuous system has been devised, the best known example of which is the Harmonic Analysis. Operational method can also be applied to solve such system. Heaviside himself applied this method in numerous problems of mathematical physics[18]—electromagnetic waves, heat-conductions. Bromwich[19] solved by this many problems, viz. temperature recorded by thermometers with varying outside temperature, sphere cooling by radiation, vibration of circular membranes, electrical problems in diffusion, and motion of viscous fluid. Carson,[17] like Heaviside, applied the OP. method to the solution of numerous problems connected with the propagation of disturbances over a cable and H. Jeffreys[20] solved by this method

problems of wave propagation in strings, cooling of the earth and many other similar problems. Many other workers solved various problems of mathematical physics by the application of operational calculus.

The chief peculiarity of the operational method in solving problems of continuous system consists in writing p for $\frac{\partial}{\partial t}$ in any problem in which partial equations of mathematical physics occur. For instance, in the problem of flow of heat in an isotropic solid, where we have the partial differential equation

$$\frac{\partial v}{\partial t} = h \Delta^2 v, \qquad \ldots \quad \ldots \quad \ldots \quad (26)$$

we write p for $\frac{\partial}{\partial t}$ and regarding p as an algebraic quantity and forming the *subsidiary* equation from the initial conditions, solve it by the usual methods of solving differential equations. Then we interpret the result. For simplification we write $p = h^2q^2$ and for interpretation we use the result (21) for the interpretation of e^{-qx}.

But this method raises numerous difficulties in the solution of partial differential equations of mathematical physics, i.e. of the continuous system. It, however, gives correct result in the case of discrete systems with a finite number of degrees of freedom. As has been already pointed out, the chief difficulty consists in the fact that the operational solutions of continuous systems are found to contain such expressions as e^{-ph} or e^{-hq} *, $(h > 0)$ and no expansion of the operators in powers of p^{-1} exists. This is not a fault of operational method; for, in arriving at the differential equations of the continuous systems, a limiting process has been applied, the physical meaning of which in many cases are doubtful.

It has been pointed out [21] that in one-dimensional heat-propagation in a rod of finite length, the partial differential equation (26) fails to represent the heat-propagation at $t = 0$, because the partial derivative of temperature, with respect to time at $t = 0$ and $x = 0$, is ∞ and the second partial derivative with respect to x is non-existent at $x = 0$, $t = 0$. G. Prasad [22] says that the phenomenon is represented by partial integral equation and not by the partial differential equation (26). Also in another continuous system—the vibration of a string of finite length—the first and the second derivatives of displacements are discontinuous at certain points and so the use of the partial differential equation

$$\frac{\partial^2 y}{\partial t^2} = c^2 \frac{\partial^2 y}{\partial x^2} \qquad \ldots \quad \ldots \quad \ldots \quad (27)$$

* Cf. Result (21).

is meaningless. The real problem is not whether the operational method gives a correct solution of the partial differential equation but what must be the modification of (27) and then to see that when we apply the OP. method to the modified equation, whether we get a solution which is correct for the actual physical system. Jeffreys' [23] idea is that the continuous system should be regarded as the limit of a discrete system. If a string be loaded at interval l with particles of mass ρl, then he finds the displacement of the rth particle as

$$\ddot{y}_r = -\frac{c^2}{l^2}(2y_r - y_{r-1} - y_{r+1}), \quad .. \quad .. \quad (28)$$

where $c^2 = P/\rho$, P being the tension. If l tends to zero, while c and ρ remain constant, so that on taking $rl = x$, the system approaches in the limit the continuous string with line density ρ and the equation (28) takes the form (27). The operator found by him for (28) in the form

$$\phi(p) = \left\{\left(1+\frac{p^2l^2}{4c^2}\right)^{\frac{1}{2}} + \frac{pl}{2c}\right\}^{-2r} \quad .. \quad .. \quad (29)$$

can now be expanded in negative powers of p, which tends to $e^{-\frac{p}{c}x}$ in the limit when l tends to zero and r to infinity with $lr = x$. The operational solution is thus justified by Jeffreys for the continuous system.

An analogous treatment of the problem whose limiting differential equation is that of heat-conduction was again given by Jeffreys.[24] A set of particles at intervals l along a light string with displacement y_r are connected by the equation

$$\dot{y}_r = \frac{h^2}{l^2}(y_{r-1} - 2y_r + y_{r+1}). \quad .. \quad .. \quad (29)$$

At $t = 0$, all $y_r = 0$; for $t > 0$, $y_0 = 1$, $y_m = 0$. If l be made very small, this equation will tend to the equation (26), the initial condition being zero everywhere and the temperatures of the terminals being 1 and 0. The operational solutions are given by

$$y_r = \frac{\sinh(m-r)\theta}{\sinh m\theta}, \quad .. \quad .. \quad (30)$$

where $\cosh\theta = 1 + \frac{pl^2}{2h^2}$. If we solve the latter relation for θ, we get

$$e^{\theta} = \left\{\left(1+\frac{pl^2}{4h^2}\right)^{\frac{1}{2}} + \frac{p^{\frac{1}{2}}l}{2h}\right\}^2. \quad .. \quad .. \quad (31)$$

Now, as the expansion of (30) is in negative integral powers of e^{θ}, we find that

$$e^{-r\theta} = \left\{\left(1+\frac{pl^2}{4h^2}\right)^{\frac{1}{2}} + \frac{p^{\frac{1}{2}}l}{2h}\right\}^{-2r} = p^{-k}\left\{\left(\frac{l^2}{4h^2}+\frac{1}{p}\right)^{\frac{1}{2}} + \frac{l}{2h}\right\}^{-2r}$$

which is expansible in negative powers of p^{-1}. Now, if l tends to zero while lr tends to x, this tends to e^{-qx}, which can be interpreted by Bromwich-Wagner theorem. Thus we can interpret y_r term by term and get the solutions also in the limit.

Symbolic Calculus and Van der Pol's Investigations.—Carson's integral and Bromwich-Wagner theorem laid the basis for what may be called the SYMBOLIC CALCULUS, which may be regarded as a new phase of Heaviside *operational calculus.* In the former the old idea of an operator and operand in the Heaviside's sense, where p stands for $\frac{d}{dt}$ is abandoned; p now stands for inversion or an operational *parameter.* Pol names it as *Symbolic Calculus*; but as Heaviside's rules of his calculus hold here also, we shall still call it the *operational calculus* in honour of Heaviside. Following Pol,[25] if $\phi(p)$ be defined by the Carson integral

$$\phi(p) = p\int_0^{\infty} e^{-px}f(x)\,dx \qquad \ldots \qquad \ldots \qquad (23)$$

when the integral is convergent, $R(p) > 0$, then $\phi(p)$ is the *operational representation* of $f(x)$ or the *Laplacian transform* of $f(x)$. This is denoted by the notation

$$\phi(p) \doteqdot f(x) \qquad \ldots \qquad \ldots \qquad \ldots \qquad (25)$$

Here $f(x)$ is the 'original' and $\phi(p)$ is the 'image'. When the *original* is given, the *image* is obtained by Carson integral (23), but if the image is known, the original is obtained by Bromwich-Wagner integral

$$f(x) = \frac{1}{2\pi i}\int_{c-i\infty}^{c+i\infty} \frac{\phi(p)}{p} e^{px}dx. \qquad \ldots \qquad \ldots \qquad (24)$$

This can also be expressed by the same notation

$$f(x) \doteqdot \phi(p)$$

as no confusion is likely to arise in finding out what is meant.*

The relations (23) and (24) are valid if either one of the following two groups of conditions, A or B, is satisfied. Many

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* Mclachlan (N. W.) suggests a new symbol $\supset$ to denote 'the operational form of'. According to him, (25) would be written as $f(x) \supset \phi(p)$. But we stick to the old notation.

other operational systems[26] are possible; but two of them, A and B, are of importance:—

A.

1. $\phi(p)/p$ is an analytic function of the complex variable p, having no points of singularity in any finite region to the right of the straight line $R(p) = c$, parallel to the imaginary axis.

2. There exists a positive number ν_0 such that

$$\lim_{|p| \to \infty} |p^\nu \phi(p)| = 0, \quad \text{for } \nu > \nu_0,$$

where $R(p) > c$.

B.

1. $\phi(p)/p$ is an analytic function of the complex variable p, having no points of singularity in any finite region situated to the right of two lines, L_1 and L_2, defined by $p = c + re^{\pm i\phi}$, $\frac{\pi}{2} < \phi < \pi$.

2. A positive number ν_0 exists such that

$$\lim_{|p| \to \infty} \left| p^\nu \frac{\phi(p)}{p} \right| = 0, \quad \text{for } \nu > \nu_0,$$

p being to the right of L_1 and L_2.

Operations satisfying either condition A or B are known as restricted operations. Solutions concerning dissipative electric network, and many other electrical and mechanical problems are always expressed by restricted operators.

Van der Pol[25] showed how his method of symbolic calculus could be used to obtain the *Power Series Rule* and *Partial Fraction Rule* of Heaviside. Besides, he had also built up certain powerful rules which were of utmost importance in this calculus. Pol and Nissen[27] applied those rules and obtained the operational representations of some of the important functions known to occur in the problems of mathematical physics and in transient electric problems. These will be found in papers published by them and by many other workers in the field.

Solutions of Linear Differential Equations.—The method developed by Pol was used by him to solve linear differential equations with constant as well as variable coefficients[28]. It thus finds an immediate application to the solutions of the differential equations of mathematical physics. His method consists in multiplying the differential equation after a suitable change by e^{-px} and then integrating every term between 0 and ∞, by parts, putting in the initial conditions for the unknown function and then writing the operation form by the help of Carson integral (23). By this he shows that there exists a close analogy between the Laplacian transformation and his operational

solution. The method is a modification of the familiar method of solutions of differential equations by definite integrals[29]. It is more powerful than the ordinary method of integration.

This operational method has many advantages over the ordinary method in those cases of functions which are much too complicated and cannot be expressed directly by more elementary functions. Van der Pol and Nissen [27] were the first to demonstrate that by the help of operational representations and by the rules of the calculus old properties of known functions can be easily established and new ones obtained. It very often happens that the operational representations of complicated functions are given by rather elementary functions and from the known properties of the latter, many old and new properties of the former can be obtained and proved. Contemporary literature on this subject is vast and many deal with such problems.

Functions of Mathematical Physics.—Functions of mathematical physics were formerly studied from their expressions in series and integrals. Most of their expressions being complicated power series, it was not possible to deal with them completely in that manner. With the invention of the new technique of the operational calculus, it was found to be easy to deal with them and to study their properties. Van der Pol and Nissen showed the way. After them other workers [30] have taken up the problem. The literature is so vast that it is not possible to do full justice to it now in this short address. I shall, however, mention the works of the few who are working in this field.

Van der Pol and Nissen [27] were the first to study the properties of Bessel's and Legendre's functions by the help of operational representations and the rules of the symbolic calculus. They gave the operational representations, and their properties following from them, of the following: *Meander* Function, the *Staircase* Function, *Hermite* and *Laguerre* Polynomials. Many infinite series and integrals of functions whose operational representations are known, were also evaluated by them.

Pol and Nissen [31] introduced the method of simultaneous operational calculus to evaluate integrals involving products of Bessel's functions. Shastri [32] then used the same method to sum up a series of products of two generalized Laguerre polynomials and the Neumann's series for the product of two Bessel's functions.

Goldstein [33] and Dhar [34] worked out the operational representations of the W-functions from two different points of view and obtained various relations connected with them. Further Dhar[35] obtained the operational representations of M-functions and studied their properties.

Mitra [36] obtained the operational representation of the squares of parabolic cylinder functions. Varma [37] worked out

various problems in connection with the parabolic cylinder functions. Howell [38] worked on Laguerre polynomials of the generalized form. Following the work of Dhar [39] on an expression for the product of two parabolic cylinder functions with different argument, Howell [40] gave an operational representation of the product of two parabolic cylinder functions with different arguments and also that of two Laguerre polynomials.

Mclachlan and Meyers [41] worked out various operational forms for Bessel's and Struve functions, ster and stei functions and worked out many problems connected with submarine cables.

The operation forms were made use of in finding out self-reciprocal functions of the Hankel transforms [42]. Varma [43] found out the Hankel transforms of the parabolic cylinder functions; and Dhar [44], Hankel transforms of the W-functions. Erdelyi [45] investigated certain Hankel transforms also of the W-function.

II. The Automorphic Functions and Uniformization Problems

I shall now deal with the second part of my address. Shortness of space will require me to be brief.

Introduction.—The *automorphic functions* are the natural generalization of the circular and the elliptic functions. Now the circular functions, $\sin z$, $\cos z$ for instance, are invariant for the group of discontinuous transformations denoted by $(z, z+2n\pi)$, where n is an integer. The complex plane is thus divided into parallel strips of width 2π with sides parallel to the imaginary axis. Each strip is called a *fundamental* region, because no two points in it are *congruent* for the above group of transformations. The same values of the function are repeated from strip to strip. Thus for the purpose of studying such functions, it is sufficient if we study them for points within a fundamental region.

Circular functions are *singly periodic* functions. There are functions which are *doubly periodic*. If $f(z)$ be any function of z such that

$$f(z+2w_1) \equiv f(z) \text{ and } f(z+2w_2) \equiv f(z) \quad .. \quad (32)$$

for all values of z, w_1 and w_2 being any two numbers, real or complex, whose ratio is not purely real, then $f(z)$ is a doubly periodic function. A doubly periodic function, analytic and having no singularities other than poles in the finite part of the plane, is called an *elliptic function.* According to the nature of the poles, elliptic functions are divided into two classes: (i) Weierstrassian elliptic function $\wp(z)$, and (ii) Jacobian elliptic functions $sn\, z$, $cn\, z$, $dn\, z$. The fundamental region for a doubly periodic function is the period parallelogram obtained by joining

the points $(0,\ 2w_1,\ 2w_1+2w_2,\ 2w_2)$. The group of transformations which keep such functions unaltered is given by $(z,\ z+2mw_1+2nw_2)$, where m and n are any integers.

Automorphic functions.—Extending the same idea, we will define *automorphic functions* to be those functions which are invariant with respect to the group of transformations which change z into

$$\frac{a_r z+b_r}{c_r z+d_r},\quad (r = 1, 2, 3, \ldots\ldots)$$

Poincare [46] was the first to discover such functions. He called them by the names (i) Fuchsian Function, and (ii) Kliennian Function. But Klien [47], instead, proposed that they should be called under the general name—*automorphic functions.*

Problem of Uniformization.—The importance of automorphic function is due chiefly to the fact that by means of them the 'uniformization problem' can be solved. Now, functions are either one-valued or many-valued. Rational and integral functions are one-valued functions. The problem of uniformization is one of reducing many-valued functions into single-valued functions. This is of importance in analysis and in the theory of curves. If u be an algebraic function of z defined by

$$f(u, z) = 0 \qquad \ldots \qquad \ldots \qquad \ldots \qquad (33)$$

so that u is in general a many-valued function of z, then the problem of uniformization is to find a third variable t, called the 'uniformizing variable', so that u and z can be expressed as single-valued functions of t, satisfying (33). Such functions are *automorphic functions.*

When the equation (33) is of genus zero, the automorphic functions in question are merely rational algebraic functions; when it is of genus unity, automorphic functions are elliptic functions. Thus, if the curve of genus unity be taken in the normal form

$$u^2 = 4z^3-g_2z-g_3z, \ldots \qquad \ldots \qquad \ldots \qquad (34)$$

then it can be uniformized by taking

$$\left.\begin{aligned} z &= \wp(t) \\ u &= \wp'(t). \end{aligned}\right\} \qquad \ldots \qquad \ldots \qquad \ldots \qquad (35)$$

If, on the other hand, we take the normal curve in the form

$$u^2 = z(1-z)(1-k^2z),$$

where k is real, then the uniformizing variable is

$$t = \int_0^z \frac{ds}{\sqrt{s(1-s)(1-k^2s)}}. \qquad \ldots \qquad \ldots \qquad (36)$$

Klien's formulation of the problem.—Klien's formulation of the general problem of uniformization of an algebraic curve is the following:—

The algebraic curve given by $f(u, z) = 0$ can be represented on a Riemann surface of genus p (say), so that corresponding to every pair of values (u, z) there is a point on the surface. By drawing two-point cuts, we can make the surface singly connected.

Now, let z be regarded as a function of a new variable t having the following properties:—

(i) the dissected Riemann's surface is to be conformally represented on a plane area in the t-plane bounded by $4p$ curvilinear sides, viz. the conformal representations of the cuts, each cut giving two sides;

(ii) of the two sides of the t-plane which correspond to any cut, one is to be derivable from the other by a substitution

$$\left(t, \frac{at+b}{ct+d}\right);$$

(iii) the group formed by the combination and repetition of these $2p$ substitutions is to be *discontinuous* group.

When a variable t has been found satisfying these conditions, u and z will be single-valued and automorphic functions of t.

Poincare's method.—Poincare [48] approached the problem of uniformization from the other end. Instead of starting from the algebraic curve $f(u, z) = 0$ and trying to find the group of substitutions and the uniformizing variable t, he started with the group of substitution and tried to form automorphic functions of the group.

He formed the Thetafuchsian functions

$$\theta(t) = \sum_{r=1}^{\infty} (c_r t + d_r)^{-2m} H(t_r), \quad (m > 2) \quad .. \quad (37)$$

where $H(t)$ is any function of t which in the interior of the fundamental circle has only a finite number of poles. Poincare showed that if $\phi(t) = \dfrac{\theta_1(t)}{\theta_2(t)}$, then $\phi(t)$ is an automorphic function for the group of transformations $\left(t, \dfrac{a_r t+b_r}{c_r t+d_r}\right)$, $a_r d_r - b_r c_r = 1$.

Study from the point of view of Linear Differential Equations.—Take the case of the uniformization of algebraic curve of genus

one. The uniformizing variable t is the quotient of two integrals of the linear differential equation,

$$\left.\begin{aligned} &\frac{d^2y}{dz^2}+p(z)\frac{dy}{dz}=0, \\ \text{where} \quad &\frac{d^2t}{dz^2}+p(z)\frac{dt}{dz}=0, \quad t \text{ being given by (36).} \end{aligned}\right\} \quad .. \quad (38)$$

These reduce to the linear differential equation

$$\frac{d^2y}{dz^2}+\frac{1}{2}\left(\frac{1}{z}+\frac{1}{z-1}+\frac{1}{z-\frac{1}{k^2}}\right)\frac{dy}{dz}=0 \quad .. \quad (39)$$

the ratio of the two solutions of which is the uniformizing variable t for the algebraic curve of genus one. This equation can be written in the form of Riemann's P-equation as

$$y = P\begin{Bmatrix} 0 & 1 & \frac{1}{k^2} & \infty & \\ 0 & 0 & 0 & 0 & z \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} & \frac{1}{2} & \end{Bmatrix} \quad .. \quad .. \quad (39)$$

showing that y as a function of z has four singularities, the exponents at these singularities being $\frac{1}{2}$.

If now z describes a circuit round each one of the singularities $0, 1, \frac{1}{k^2}$ and ∞, t undergoes the substitutions in the following order:

$s_1 = (t_1, -t)$, $s_2 = (t, 2L-t)$, $s_3 = (t, 2L+2iL'-t)$ and $s_4 = (t, 2iL'-t)$,

where

$$L = \int_0^1 \frac{ds}{\sqrt{s(1-s)(1-k^2s)}} \text{ and}$$

$$L' = \int_0^1 \frac{ds}{\sqrt{s(1-s)(1-k'^2s)}}, \quad k'^2+k^2=1$$

and also we get

$$s_1s_2s_3s_4 = 1,$$

which are the group of substitution for the automorphic function.

Whittaker Group.—More generally it has been proved that the uniformizing variable t for the algebraic curve $f(u, z) = 0$,

z and u being simple automorphic functions of t, is the quotient of the two solutions of the differential equation

$$\frac{d^2y}{dz^2}+uy=0. \quad .. \quad .. \quad .. \quad (38)$$

If u has a single pole of the first order in the fundamental region, then u is a rational function of z.

Prof. Whittaker [49] has shown that the uniformizing variable for the hyper-elliptic curve of genus p,

$$u^2=(z-e_1)(z-e_2)\ldots.(z-e_{2p+2})$$

is the quotient of two solutions of the linear differential equation

$$\frac{d^2y}{dz^2}+\frac{3}{16}\left[\sum_{r=1}^{2p+2}\frac{1}{(z-e_r)^2}\right.$$

$$\left.+\frac{-(2p+2)z^{2p}+2pp_1z^{2p-1}+c_1z^{2p-2}+c_2z^{2p-4}+\ldots+c_{2p-1}}{(z-e_1)(z-e_2)\ldots.(z-e_{2p+2})}\right]y$$

$$=0, \quad .. \quad (39)$$

where $p_1=\sum_{r=1}^{2p+2}e_r$, and $c_1, c_2 \ldots.$ are constant as yet undetermined, and which are to be determined by the condition that the group of substitutions, which the quotient of two solutions undergoes when z is taken on a path round the singularities $e_1, e_2 \ldots. e_{2p+2}$, is a *discontinuous* group and *self-inverse*, leaving invariant a circle in the t-plane. These are the ***Whittaker group*** for the automorphic functions.

Whittaker also considered the case of the hyper-elliptic curve of genus two

$$u^2=(z-e_1)(z-e_2)\ldots.(z-e_6). \quad .. \quad (40)$$

He showed that the fundamental region is a curvilinear octagon and if we piece together the corresponding sides with respect to the groups, we get a surface of genus two.

Determination of the Constants.—The constants $c_1, c_2 \ldots. c_{2p-1}$, which are to be determined from the circuits round the singularities $e_1, e_2 \ldots.$, remained undetermined for a long time and the progress of the theory arrested for a whole generation. Whittaker tried to solve the difficulty by taking accounts of the fact that the determination of $c_1, c_2 \ldots$ must be an invariant one. He was led to infer that if the hyper-elliptic curve be written as

$$u^2=f(z)\equiv(z-e_1)(z-e_2)\ldots(z-e_6),$$

then equation (39) must be of the form

$$\frac{d^2y}{dz^2}+\frac{3}{16}\left(\frac{f'^2}{f^2}-\frac{6}{5}\frac{f''}{f}\right)y=0 \quad \ldots \quad \ldots \quad (41)$$

which can be transformed into the simplest form

$$\frac{d^2u}{dw^2}+\frac{1}{40}f''(z)u=0, \quad \ldots \quad \ldots \quad (42)$$

where $w=\int\frac{dz}{u}$ and $u=f^{-\frac{1}{4}}y$.

Whittaker [50] verified the inference for the curve $u^2=z^5+1$ and showed that the fundamental region for the groups of transformations he obtained is a curvilinear octagon and the uniformization of the algebraic curve belonging to the form $u^2=z^5+1$ is thus effected by the automorphic functions of the group, the fundamental transformations of which are obtained easily. These functions Whittaker denotes as ***hyper-lemniscate functions***.

From Poincare's existence theorem that there is one and only one set of values of $c_1, c_2 \ldots$ for which the group of (39) is 'funchsion', J. M. Whittaker [51] proceeded to determine the values of $c_1, c_2 \ldots$ and obtained certain conditions which the constants must satisfy. He showed that when $f(z)\equiv(z-e_1)\ldots.(z-e_6)$, (41) must be the true form of the equation (39). Hence he inferred that

$$\frac{d^2y}{dz^2}+\frac{3}{16}\left[\left\{\frac{f'(z)}{f(z)}\right\}^2-\frac{2p+2}{2p+1}\frac{f''(z)}{f(z)}\right]y=0 \quad \ldots \quad (42)$$

must be the true form of (39) for the hyper-elliptic case $u^2=(z-e_1)\ldots(z-e_{2p+2})$.

Next, Murse [52] verified (42) for the case of curve $u^2=1+z^7$ of genus *three*. Dhar [53] then considered the case of curve of genus *four*. Next, Dhar [54] obtained the group of transformation of algebraic curve of hyper-elliptic form of *any genus* and showed that (42) is the true form of (39).

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SECTION OF PHYSICS

President :—H. J. BHABHA, F.R.S.

Presidential Address

(Delivered on Jan. 4, 1943)

RECENT ADVANCES IN THE THEORY OF FUNDAMENTAL PARTICLES

I propose to speak today about the very far-reaching development which has taken place in the last few years in our ideas about matter and the physical world in general.

The earliest form of scientific activity in the world of inanimate matter consisted mainly in a recording of the facts of accurate observation. It was found very early in the evolution of physics that certain properties, which could be stated in terms of exact measurement, were common to many objects. In certain cases, therefore, it became possible to state a general property without specifying the particular object to which it belonged. Such general properties could be regarded as laws or 'regularities' of nature which all objects of a certain type satisfy. These regularities were, however, merely empirical statements of facts of observation found to be common to a large number of objects, and had no theoretical basis. An example of a regularity or law of this type is the one discovered by Archimedes, that the loss in weight of an object immersed in water is equal to the weight of water displaced. Another regularity is that discovered by Galileo, that all bodies fall a given distance under gravity in the same time, irrespective of their weight. More elaborate regularities of the same type, but which concern more abstract properties of the objects, are the three laws of Kepler on the motion of the planets.

Newton's fundamental laws of dynamics and gravitation, on the contrary, are not of the same type since they are not a record of the facts of observation and cannot be proved by direct experiment. They must be regarded as fundamental postulates or assumptions from which observable properties of objects can be deduced by mathematical calculation. The proof of the correctness of the Newtonian postulates was that the results derived from them mathematically were in agreement with all the observed facts that were known then. For example, the law of Galileo on the fall of bodies under gravity and the laws of

Kepler could both be deduced from these. The great importance of the contribution of Newton to the development of physics is that it introduced a new *approach* into science. It led to the acceptance of the position that the ideas which are to be regarded as fundamental for the understanding of nature are certain abstract concepts and postulates which cannot be proved directly, and not the directly observable regularities of nature which can be deduced from them. This position was accepted because it allows one to order different empirically found regularities of nature into a unified logical scheme which would not otherwise be possible.

A consequence of this approach is that any newly discovered fact of nature which does not fit into the existing scheme of physics may necessitate a complete change of the fundamental postulates. Since, however, the old postulates were such that a very large body of observed facts about nature could be deduced from them, it follows that they must still have a restricted validity under certain circumstances, and be deducible as approximations from the new postulates. Although, therefore, every time a new discovery which does not fit into the old scheme necessitates a complete change of the fundamental postulates, the change is always from a certain set of concepts to a set of more general concepts. As one goes deeper and deeper into the understanding of nature by co-ordinating all the known facts into one scheme by the use of wider concepts as the basic postulates, the old fundamental postulates become, in a sense, a part of the superstructure taking a place in between the new fundamental concepts and the directly observed regularities of nature.

As an example of this process of generalization of the basic concepts, one may recapitulate the well-known development from the pre-relativity concepts of an absolute space and an absolute time to the more general concept of the unified space-time of the theory of relativity. In pre-relativity physics, in recognition of the arbitrariness of the orientation of the three axes of the frame of reference, the natural laws were formulated so as to be invariant for all rotations of the space axes. Time, on the other hand, was assumed to be absolute and the same for all observers. However, in consequence of the observation that the velocity of light c is the same for all observers in uniform motion relative to each other, the idea of absolute rest has had to be discarded leading to the principle of relativity, which demands that the laws of nature should be so formulated as to have the same form for all observers moving relative to each other with uniform velocity. Stated mathematically, the special theory requires that the fundamental equations shall be invariant for all transformations of the Lorentz group, whereas in pre-relativity physics the laws were only invariant for all transformations of the three dimensional rotation group, which is a sub-group of the Lorentz group.

Although the absoluteness of time has been discarded in the theory of relativity, nevertheless it is possible to carry many of the pre-relativity concepts over into the relativity theory. The fundamental invariant connected with two events separated from each other by the time t and the space co-ordinates x, y, z is the square of their absolute distance defined by

$$c^2t^2-x^2-y^2-z^2 \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

Whereas the four co-ordinates t, x, y, z are relative and depend on the observer, the absolute distance has a real physical meaning independent of the observer, and the theory of special relativity allows all transformations which leave this quadratic form invariant. A space for which (1) is the fundamental invariant form is called hyperbolic. It is obvious from (1) that the time co-ordinate is not on the same footing as the other three space co-ordinates since it enters in (1) with the opposite sign. This is of vital consequence, for it enables the general concepts of pre-relativity physics to be taken over into relativistic theory and given a wider meaning consistent with the principle of relativity. For example, two events may be said to be contemporary if they are separated by a space-like interval, that is, if the expression (1) is negative for them, for then there is at least one frame of reference for which these two events are simultaneous in the pre-relativity sense. An event B can be said to be subsequent to an event A if it is separated by a time-like interval from the other and is at a later time, that is, if the expression (1) is positive, for then this relation between A and B is again the same for all observers. In relativistic theory 'the present' may therefore be defined as any three dimensional surface all points of which are contemporary, that is, any space-like surface. The pre-relativity concept of the present as a three dimensional plane surface perpendicular to the time axis is obviously a particular case of this. It is also well known that for all observers in relative motion with velocities small compared with that of light the time of any given event is approximately the same and we obtain the Newtonian idea of an absolute time as an approximation for this group of observers.

The hyperbolic nature of space is intimately connected with the nature of the partial differential equations satisfied by the field functions which describe the behaviour of the fundamental entities of nature, and requires that the partial differential equations shall also be hyperbolic. Indeed, the requirement that the formulation of the natural laws shall be invariant for all transformations of the Lorentz group, that is, all transformations which leave the form (1) invariant, has as a consequence that the simplest invariant differential operator is

$$\frac{\partial^2}{c^2\,\partial t^2}-\frac{\partial^2}{\partial x^2}-\frac{\partial^2}{\partial y^2}-\frac{\partial^2}{\partial z^2} \quad \ldots \quad \ldots \quad (2)$$

The simplest invariant partial differential equations for one function are therefore the wave equation

$$\frac{\partial^2 u}{c^2 \partial t^2} - \frac{\partial^2 u}{\partial x^2} - \frac{\partial^2 u}{\partial y^2} - \frac{\partial^2 u}{\partial z^2} = 0 \qquad \ldots \qquad \ldots \qquad (3)$$

and the generalized wave equation

$$\frac{\partial^2 u}{c^2 \partial t^2} - \frac{\partial^2 u}{\partial x^2} - \frac{\partial^2 u}{\partial y^2} - \frac{\partial^2 u}{\partial z^2} + \chi^2 u = 0 \qquad \ldots \qquad (4)$$

where χ is an invariant. Although simultaneous partial differential equations for several unknown field functions play an important rôle in the theory of the elementary particles of nature, it can be shown that in free space each of these field functions satisfies one of the equations (3) or (4), so that these essentially determine the structure of the solutions. From the point of view of field theory, and consistently with the definition of the present just given, a future epoch may be defined as any other space-like surface which does not touch the space-like surface called the present at any point, and lies on the side of increasing time. The fundamental equations (3) or (4) are just such that they allow an unknown field function to be calculated uniquely at any point of space, given the function and its first derivatives on some *space-like* surface. In other words, they give a complete answer to precisely the problem that confronts us in physics, and allow the field functions to be calculated on a future space-like section, given their values and derivatives on a previous space-like section. The aim of physics of calculating the future from the present is thus carried over into relativistic field theory by being given a more general meaning.

The widening of the basic concepts does not, however, have as a consequence that there is more arbitrariness in the theories that can be built upon the basis of these concepts. On the contrary, the demand that the theory shall be invariant for a larger group of transformations results in a very drastic reduction of the arbitrariness in building up the theory, and it is precisely as a result of this that we are today beginning to get a new insight into the inevitability of the structure of the physical world. For example, while in non-relativistic theory the interaction between two particles can be chosen entirely arbitrarily and is only determined empirically, in relativistic theory the interaction can no longer be given by an arbitrary static function, for such a description would not be relativistically invariant. In relativistic theory any long distance interaction between two particles must be carried through the medium of a field, and the field functions of this field must satisfy one of the equations (3) or (4) in free space. The type of interaction possible between two fundamental particles is therefore very drastically limited. The interaction between two heavy particles, say a proton or a

neutron, is a case in point. While non-relativistic theory imposes no restriction at all on the variation of the mutual potential energy with distance r, relativistic invariance almost inevitably requires that in the static case it should be

$$\frac{e^{-\chi r}}{r} \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

or a combination of this function and its derivatives. As another and somewhat different example one may cite the interaction of an electron with the radiation field, or a proton with the meson field, each of which in relativistic quantum theory is limited to only two terms which can be introduced multiplied by arbitrary constants corresponding to the charge and magnetic moments respectively of the particle.

While the demands of relativistic invariance impose certain drastic limitations on the type of theory that can be built up, the requirements of the quantum hypothesis impose other limitations. The limitations imposed by both requirements are so stringent that one can give at once all the theories that are possible in these circumstances. The recent progress in building up a relativistic field theory, that is, a theory which is in accordance with the demands of the principle of relativity while at the same time satisfying the requirements imposed by the existence of the quantum of action, has led to a great extension in our understanding of the structure of the physical world and also had as a consequence a widening of our ideas about the nature of the fundamental particles

It was shown by Heisenberg that as a result of the existence in nature of the quantum of action discovered by Planck it is impossible to measure the position and momentum of a material particle simultaneously with unlimited accuracy, and has therefore made it necessary to abandon the attempt to calculate the exact trajectory of a material particle in space-time and to replace this by giving the probability of the particle being found in any given region of space at a given time. The problem of the mechanics of a particle therefore becomes the problem of calculating the values of a set of functions, called the wave-functions, at all points of space at a later time when their values are given throughout space at an earlier instant of time, such physical properties associated with the particle as energy, momentum, current, etc. being calculable from these functions. Thus quantum mechanics, especially in its relativistic form, makes the theory of the motion of material particles also one of field theory, and hence dependent on the properties of partial differential equations. The postulate of relativistic invariance now imposes a stringent restriction on the possible wave equations which can be set up to describe the behaviour of material particles. The equations have to be invariant under all transformations of the Lorentz group and hence the only quantities which can enter

into these equations as field functions must be spinors or tensors. The possible wave equations which can be set up can be shown to describe elementary particles or quanta with a spin equal to $\hbar$ times some given integer or half-odd integer. These wave equations have been given by Dirac, Fierz and Pauli.

The theory of fundamental particles owes its rapid development to the theoretical realization that it is impossible to formulate a one-body problem in relativistic quantum mechanics, and the remarkable confirmation of this fact by the discovery of the positron and the process of pair creation. It is, however, possible to formulate a one-body problem in classical relativity theory and also in non-relativistic quantum mechanics, and only the attempt to combine both relativity and quantum mechanics leads to the difficulty mentioned. The reason is fundamental and easy to see.

In non-relativistic theory the kinetic energy E_{kin} of a free particle of mass m is connected with its momentum p by the formula

$$E_{\text{kin}} = \frac{p^2}{2m} \qquad \ldots \quad \ldots \quad \ldots \quad (6)$$

and is therefore always positive. In non-relativistic quantum theory this equation becomes translated into the Schrodinger equation, and E_{kin} has in consequence only positive eigenvalues for a free particle. In relativity theory, on the other hand, the total energy E of a free particle is given by

$$E = \pm c\sqrt{p^2+m^2c^2} \qquad \ldots \quad \ldots \quad (7)$$

This expression shows that the energy E can take on all values greater than mc^2 and less than $-mc^2$. It can easily be shown that a particle with negative energy would behave like a particle of negative mass, and in consequence suffer an acceleration in a direction opposite to any force exerted on it. No such particle is known in nature. The negative values of the energy can, however, be avoided easily in classical theory by merely postulating that all particles in nature had initially positive energies. Since all magnitudes in classical theory change continuously, and there are no allowed values of the energy between $-mc^2$ and $+mc^2$, it follows that all particles would always continue to be in positive energy states. The difficulty arises in relativistic quantum theory because a particle can jump from one state to another, and hence particles would after some time be found in states of negative energy even if all particles were in positive energy states at the beginning. Equation (7), which holds irrespectively of the spin of the particle, is the root cause of the difficulty of negative energy states first encountered in connection with Dirac's theory of the electron, and necessitates the development which will be outlined now.

The solution of the difficulty of the negative energy states by Dirac is well known. We postulate that in a 'vacuum' all the negative energy states in nature are occupied each by one electron, and that the resulting distribution of charge, which is infinite and uniform everywhere, produces no field. Since electrons obey the Pauli exclusion principle, so that no two electrons can occupy the same state simultaneously, this prevents an electron in a positive energy state from falling into a negative energy state. It is important to note that this solution of the difficulty of the negative energy states only works if the particles concerned obey the exclusion principle, and in consequence satisfy the Fermi-Dirac statistics.

An immediate consequence of this solution is that it is possible on occasion for a particle in a negative energy state to jump into a positive energy state. The empty negative energy state or 'hole', being a deviation from the uniformity of the vacuum, becomes observable as a particle of the same mass, but a positive charge, while the electron which has now jumped to a positive energy state becomes observable as a real electron. The theory therefore definitely predicts, first, the existence of a particle of equal mass but opposite charge called a positron, and secondly, the possibility of an electron and a positron being *created* together in pairs if sufficient energy is available. The discovery of the positron by Anderson, and the demonstration of the pair creation process in cosmic ray showers by Blackett have provided the most remarkable confirmation of these two predictions of the Dirac theory. It is, therefore, obvious that a one-body problem in relativistic quantum mechanics is impossible since, even if we start with one particle at the beginning, the number of particles can be increased by the process of pair creation, and subsequently decreased by the reverse process of annihilation in pairs. As a consequence it is no longer correct to demand that the mathematical expression which gives the charge density of the particles at any point of space shall always be positive. This realization immediately makes it possible to interpret in a physically sensible way the relativistic wave equations describing particles of any integral or half integral spin, as has been done by Dirac, Fierz and Pauli.

One of the most remarkable achievements of relativistic quantum mechanics is a consequence of this development. A many-particle theory in which the number of particles is not constant can only be interpreted with the help of two tensors. One is the energy momentum tensor, one component of which gives the energy density of the particles at any point of space, and the other is the charge current vector, one component of which gives the charge density at any point of space. It now appears that for all particles of half integral spin the total energy is not necessarily positive. This is the same difficulty that occurs in the Dirac electron theory and can be solved in the same way by

postulating that the particles satisfy the Fermi-Dirac statistics and that the vacuum corresponds to the condition in which all the negative energy states are occupied each by one particle. *We conclude that a physically sensible theory of particles of half integral spin satisfying the Einstein-Bose statistics is impossible.* For all particles of integral spin, on the contrary, the total energy in space is always positive and the negative energy difficulty superficially does not seem to appear in this case. On the other hand, the charge density is no longer always positive as in the case of particles of half integral spin. It can be shown that as a result *the theory cannot be quantized in a way which leads to Fermi-Dirac statistics for the particles.* The theory can only be quantized in accordance with the Einstein-Bose statistics, and the fact that the total charge is not a positive definite form then leads at once to the existence of particles of both signs of the charge and to the processes of pair creation and annihilation as in the case of particles of half integral spin. We see, therefore, as first shown by Pauli and Fierz, that *in relativistic quantum theory fundamental particles of half integral spin must satisfy the Fermi-Dirac statistics*, while particles of integral spin must satisfy the Einstein-Bose statistics. This connection between spin and statistics has long been anticipated and is in agreement with the observed facts of nature, but no theoretical reason for it could be given hitherto since in non-relativistic quantum theory particles of any spin can be made to obey either type of statistics at will. We have here a remarkable example of how a widening of the basic concepts of a theory by the unification of relativity and quantum theory leads to a drastic reduction of arbitrariness in the theory and to a consequent understanding of one of the basic properties of the fundamental particles.

Quantum theory in its present form has one serious limitation. A rigorous carrying through of all calculations leads to divergent results in higher approximation and it is usually only the first approximation in which any given effect appears that gives a physically sensible result. This difficulty was first noticed in the interaction of electrons with radiation. It was till recently believed that this defect was connected with the fact that the charge of the electron was assumed to be concentrated in a point and that the divergent results were the quantum counterpart of the classically infinite electrostatic energy of a point charge. This belief has its origin in the classical theory of an electron of finite size put forward by Lorentz. It was shown by Lorentz that the mutual electrostatic energy of the charge of the electron would effectively act as an inertial mass and that the whole mass of the electron could be assumed to be of electromagnetic origin if the radius of the electron was chosen suitably. The idea found ready acceptance since it dispenses with the necessity of postulating a mechanical mass for the electron. If, in this picture, we proceed to the limit of an electron of zero

radius, the electrostatic energy becomes infinite, and it was thought that it is this difficulty which makes itself felt in the infinities which occur in the quantum theory. The work of Dirac, Pryce and the present author has shown that this universally accepted view is false, and based on an unjustified assumption that a point particle can be considered as the limit of one of finite extension. Dirac and Pryce have shown that it is possible to make a complete relativistic classical theory of a point electron moving in an electromagnetic field, at the same time taking into account the effects of radiation reaction on the motion of the electron exactly. I have further shown that the theory can be extended to spinning particles having a dipole interaction with the electromagnetic field and that an equally complete relativistic classical theory can be made for charged and spinning particles moving in meson fields. In all these theories the particles are always treated as points, but energy and momentum are strictly conserved by exactly taking into account the reaction of the radiation field on the motion of the particles. It is thereby established that the mass of a particle can be looked on as an arbitrary mechanical constant which has nothing to do with the field the particle creates, and that the treatment of radiation reaction can be carried out with mathematical rigour for a point particle. This change in our ideas about the extension of the fundamental particles is also physically more in harmony with our present concept of the fundamental particles for the following reasons. First, a relativistic theory of elementary particles of finite extension presents fundamental difficulties. The shape of a particle is not a relativistically invariant concept, and in order to define the shape of a particle in a relativistically consistent way it would be necessary to introduce a field, other than the electromagnetic or meson fields, which would be responsible for holding the different parts of the particle together in some definite configuration. The introduction of such a field, if possible, would be *ad hoc*, and in any case more complicated than treating the particles as a point. It would also be in conflict with the idea of an elementary particle as one which cannot be made up from more elementary parts or dissected into smaller parts. Secondly, the whole classical idea of the self energy of a particle of finite extension implies that the particle can be built up by bringing the charge together from infinity, where it has no potential energy, into the actual configuration. It is obvious that in this case the electrostatic energy becomes infinite if the charge is concentrated in a point. It is, however, foreign to our present ideas of the elementary particles to look upon them as made up in this way. ***The elementary particles are given immutable entities, as far as classical theory is concerned, and the only electrostatic energy which can have a physical meaning and be capable of measurement is the mutual potential energy of several different particles depending on***

their relative positions. The work of Dirac, Pryce and the present author expresses precisely this idea in an exact mathematical form in harmony with the requirements of relativity. This idea has not yet been successfully embodied in the quantum theory. In spite of the fact that the fundamental particles are treated as points in the quantum theory, yet an unambiguous and relativistically invariant way of removing the infinites has not been found, although a limited and approximate treatment of radiation reaction can be given in so far as this merely depends on the conservation of energy.

It is instructive to compare the exact classical theory with the present quantum theory. In the classical theory the mass of the particle, the angular momentum of its spin about the spin axis and the moment of inertia perpendicular to the spin axis all enter as arbitrary mechanical constants. The particle can also be given an arbitrary charge and arbitrary magnetic and electric moments in its rest system. It is, however, possible to impose the condition that the particle shall only have a magnetic but no electric moment in its rest system. It can then be shown that an enormous simplification of the equations takes place in this case. Whereas, for arbitrary magnetic and electric moments the exact treatment of radiation reaction introduces seven arbitrary constants with 111 additional terms in the translational equations and 36 terms in the rotational equations, for the case of a particle which has no electric moment in its rest system there is only one arbitrary constant with only 34 additional terms in the translational equations and 12 terms in the rotational equation respectively. We see therefore that when radiation reaction is taken into account but not otherwise, the treatment of an elementary particle with no electric moment in its rest system is vastly simpler than the general case. This is of significance in connection with the fact that the elementary particles known in nature have only a magnetic but no electric moment in their rest systems. This special case is also given quite naturally in the quantum theory. A further simplification occurs in the classical theory if the moment of inertia of the particle perpendicular to its spin axis is put equal to zero. In the quantum theory this constant is automatically zero, in agreement with the properties of the fundamental particles as they can be deduced from experiment. This discussion shows that even the present quantum theory is an advance on classical theory in allowing only those possibilities which occur in nature in this case. The only direction in which the classical theory is an advance on the present state of quantum theory is in its exact treatment of radiation reaction and freedom from singularities.

The situation outlined above makes it plausible to suppose that the following generalization is true. When a classical theory satisfying certain general postulates leaves certain factors undetermined and allows of a number of possibilities, then the

mathematically simplest possibility is the one that actually occurs in nature. Another example of this statement is supplied by the number of dimensions of space-time. It is a fact of direct experience that space-time is four dimensional. Nevertheless, it is theoretically possible to imagine space-times with one time and any integral number m of dimensions. It is, therefore, a legitimate question to ask why the space-time of the actual world is four dimensional. This question can be answered to some extent in the sense of the above general statement by showing that four dimensional space-time is the simplest one which satisfies certain basic postulates. Let the co-ordinates required for completely locating an event in space-time be $t, x_1, \ldots\ldots x_m$, where for the moment we leave the number of dimensions of space m open, and assume that the whole of space is Galilean. We start from the following two postulates which in a sense form the basis of relativity and quantum theory respectively.

(1) There is a physical entity, light, which is such that a disturbance of infinitesimally short duration at one point of space only effects a disturbance of equally short duration at another point of space after an interval of time which is equal to that required to travel from one point to the other with the same velocity c for all observers. This velocity is a universal constant. The physical laws must be so formulated as to have the same form for all observers in motion relative to each other with uniform velocity.

(2) The behaviour of all physical entities is described by the behaviour of partial differential equations and their solutions in this $m+1$ dimensional space, the equations having the same form for all observers. These equations may involve another universal constant, Planck's constant.

The first assumption requires that for two events, whose co-ordinates differ by $dt, dx_1, \ldots\ldots dx_m$, the square of their mutual distance, defined by

$$c^2 dt^2 - dx_1^2 - \ldots\ldots - dx_m^2 \quad \ldots \quad \ldots \quad (8)$$

is an invariant. Alternatively, one may postulate that the physical laws should be invariant for all transformations of the co-ordinates, $t, \ldots\ldots x_m$, which leave the quadratic form (8) invariant. The simplest differential form which remains invariant under all transformations which leave the expression (8) invariant is

$$\frac{\partial^2}{c^2 \partial t^2} - \frac{\partial^2}{\partial x_1^2} - \ldots\ldots - \frac{\partial^2}{\partial x_m^2} \quad \ldots \quad \ldots \quad (9)$$

and hence the *simplest* invariant differential equation for a single function is the wave equation in $m+1$ dimensions

$$\frac{\partial^2 u}{c^2 \partial t^2} - \frac{\partial^2 u}{\partial x_1^2} \ldots\ldots - \frac{\partial^2 u}{\partial x_m^2} = 0 \quad \ldots \quad \ldots \quad (10)$$

If we now investigate the general solution of equation (10) we find the following remarkable facts. Spaces with even and odd numbers of dimensions, i.e. with odd or even m respectively, differ essentially from each other. If the number of dimensions of space-time is odd, then a disturbance of a given duration at a given point of space produces a disturbance at other points of space which is invariably of longer duration, although the beginning of the impulse always travels outwards with the same constant velocity (velocity of light). Space-times of an odd number of dimensions are therefore not compatible with the requirements of postulate (1). For a space-time of two dimensions, i.e. one time and one space dimension, the same situation prevails, and this is therefore also not compatible with postulate (1). On the other hand, if m is odd and greater than or equal to three, a source $g(t)$ varying with the time and situated at the origin produces a field u at a point distant r from the origin given by

$$u(r, t) = \frac{1}{2(2\pi)^{\frac{m-1}{2}}} \left(- \frac{\partial}{r\partial r} \right)^{\frac{m-3}{2}} \frac{g(ct-r)}{r} \qquad \ldots \quad (11)$$

for odd m. This shows that for all odd integral $m \geqslant 3$ a signal of given duration at the origin produces a disturbance of the same duration at all other points of space. However, the spaces with different values of m are not on the same footing. The simplest case is obviously $m = 3$, for which the differentiation in (11) disappears, and the disturbance at all points has the same variation with time as the source at the origin. For all larger values of m this is no longer so, due to the appearance of the derivatives of g. Hence, as pointed out by Courant, four dimensional space-time is distinguished from all others in the property of being the only one in which signals are propagated undistorted, provided, of course, the second order equation (10) is the basic equation of physics. For higher order invariant equations formed by repeating the operator (9) any given number of times one does in special cases obtain equations for which the solutions give undistorted propagation of disturbances. It is extremely doubtful if these equations could be carried over into the quantum theory. *Quite apart from this, however, it is clear that four dimensional space-time is mathematically the simplest space-time for which the requirements of the first postulate are satisfied.* Although, therefore, as in the case of the spin of a fundamental particle discussed above, the classical theory does not definitely exclude space-time of an even number of dimensions greater than or equal to four, yet it shows that four dimensional space-time is the simplest one compatible with the two assumptions outlined above, and therefore gives an indication why space-time might be theoretically expected to be four

dimensional. It is legitimate to hope that the final theory of physics will establish an inevitable connection between the number of dimensions of space-time and its other basic concepts.

Before concluding, I must say a few words about the development of our concept of the 'fundamental' or 'elementary' particles. The concept of the elementary particles developed chiefly out of the researches of J. J. Thomson and Rutherford. The establishing of the fact that there is a minimum unit in which negative electricity occurs in nature and the subsequent discovery that this unit of electricity is always associated with the same mass led to the development of the concept of the electron as an elementary particle of mass m and charge $-e$. These were the only two facts known about the electron from direct experiment. All beliefs about its size, shape, etc. were based on thereoretical ideas about its structure developed mainly by Lorentz. As the previous discussion has indicated, these ideas about the structure of the electron have been abandoned, and the idea that the electron is a point is gaining acceptance. There is, however, one additional fact about the electron which has also been established by experiment, namely, that the electron has a spin and associated with it always the same constant angular momentum $\frac{1}{2}\hbar$. The investigations on the structure of the atom by Rutherford, establishing the existence of the nucleus, or heavy core, having a positive charge equal to some integral multiple of e and a mass over charge ratio some two thousand times greater than that of the electron led to the acceptance of the existence of another elementary particle in nature, the proton. The three experimentally established facts about the proton are that it has a positive charge e, the smallest known unit of positive electricity, always associated with the mass M, which is some 1,840 times the mass of the electron, and a spin with an angular momentum $\frac{1}{2}\hbar$.

The electron and proton were for many years the only elementary particles known in nature and it was assumed that all the material structures of nature could be built up from them. They were elementary in the sense that they could not be broken up into constituent parts, and were in consequence assumed to be permanent and immutable. On the other hand, an atom is not an elementary particle in that it consists of a heavy nucleus surrounded by a number of planetary electrons. The charge and mass of the nucleus, the only two facts then known about it, could be explained by considering the nucleus to be made up of the required number of protons to make up its mass, the resulting positive charge being partly compensated by adding the requisite number of electrons to the nucleus. This picture was consistent with the existence of the β-radioactive elements, which disintegrate spontaneously by emitting electrons from the nucleus.

The progressive movement away from this simple picture is due to both theoretical and experimental reasons. It soon became evident that electrons could not exist in the nucleus in the sense in which they exist in the outer shell of the atom. For it could be shown from the analysis of the fine structure and hyperfine structure of spectra that both the electron and proton have a spin $\frac{1}{2}\hbar$ and obey the Fermi-Dirac statistics, whereas it was found that the spin and statistics of a nucleus seemed to depend only on the number of protons in it, the electrons in the nucleus contributing nothing to either. Further, it can be deduced from the Dirac equation, which undoubtedly describes the behaviour of electrons correctly, that no electron can be bound in a region as small as the nucleus, whatever the potential energy binding it to the nucleus. This is due to the fact that if the potential function becomes very narrow and deep, the electron escapes from the nucleus in a state of negative energy.

The discovery of the neutron by Chadwick provided a solution of these difficulties while at the same time necessitating an extension of our concept of the elementary particles. The neutron has very nearly the same mass as a proton, no charge, a spin $\frac{1}{2}\hbar$ and again obeys the Fermi-Dirac statistics. The same difficulties occur in thinking of a neutron as made up of protons and electrons as in the case of nuclei. For example, if a neutron were made up of a proton and an electron its spin would necessarily be an integral multiple of $\hbar$, and it would obey the Einstein-Bose statistics, both of which are contrary to fact. The neutron must, therefore, be considered as another elementary particle of nature having no charge, a given mass, and a spin angular momentum $\frac{1}{2}\hbar$. All nuclei can then be built up of protons and neutrons without any further difficulty. Now, however, the phenomenon of the β-decay requires a revision of our ideas of the elementary particles, for to explain it we must postulate that whenever it takes place, a neutron turns into a proton giving birth to an electron in the process, much as a quantum of light is emitted by an atom. Since protons, neutrons and electrons each have a spin angular momentum $\frac{1}{2}\hbar$, conservation of angular momentum requires that another elementary particle of spin angular momentum $\frac{1}{2}\hbar$ and no charge be also emitted in the β-decay process. This particle whose mass can be shown to be small compared with that of the electron, if not exactly zero, was first postulated by Pauli and is called a neutrino. The process of the β-decay is then described by

$$\text{neutron} \rightarrow \text{proton} + \text{electron} + \text{neutrino} \quad .. \quad (12)$$

The discovery of the positron, or alternatively, the acceptance of Dirac's 'hole' theory also makes the following process possible:

$$\text{proton} \rightarrow \text{neutron} + \text{positron} + \text{neutrino} \quad .. \quad (13)$$

The process of the β-decay together with the discovery of the positron and the processes of pair creation and annihilation have forced a revision of our concepts of the elementary particles. The elementary particles can no longer be regarded as permanent and immutable. On the contrary, the lighter ones can be created in pairs, for example by the materialization of quanta of radiation, and in addition also created when a proton changes into a neutron or *vice versa*. This development has been still further extended by the discovery of a new elementary particle, the meson, in cosmic radiation.

The first postulation of a particle of charge $\pm e$ but a mass μ intermediate between those of the proton and electron occurs in a theory put forward by Yukawa. The facts known about the mass defects and stability of nuclei requires that the forces acting between two heavy particles in a nucleus, say a proton and a neutron, must be of short range, that is, they must diminish with distance far more rapidly than the electrostatic force between two charged particles, and in addition be some hundred times stronger. Since the idea of action at a distance is foreign to modern physics, a force between two particles separated by a finite distance can only act through an intermediate field. It then follows from quite general considerations that the components of this field in free space must satisfy the generalized wave equation (4). The force between two heavy particles is then given by (5) or a combination of this function and its derivatives. The force therefore falls away rapidly with distance as is required and comparison with experiment then determines the constant χ. It can be shown that the field must be connected with particles whose rest mass μ is given by $\mu = \dfrac{h}{\chi c}$. This leads to a mass of approximately 170 times the electron mass. In order to take account also of the fact that the force between a proton and a neutron is an exchange force, that is, that a proton turns into a neutron and a neutron into a proton every time the two particles interact, Yukawa postulated that the interaction takes place through the intermediary of particles of charge $\pm e$ and the mass μ, thus

$$\begin{aligned} &\text{proton} \rightleftarrows \text{neutron} + \text{positive meson} \\ &\text{neutron} \rightleftarrows \text{proton} + \text{negative meson} \end{aligned} \qquad .. \quad (14)$$

The discovery of particles in cosmic radiation with a mass of this order and both positive and negative charge must be regarded as a confirmation of the general idea of the Yukawa theory. The β-decay is fitted into this theory by assuming that the processes (12) and (13) really take place in two steps. The first step is given by (14), the mesons being constantly emitted

and re-absorbed by the heavy particles for periods so short that they could never be observed. The second step is

$$\begin{aligned} &\text{positive meson} \rightleftarrows \text{positron} + \text{neutrino} \\ &\text{negative meson} \rightleftarrows \text{electron} + \text{neutrino} \end{aligned} \qquad .. \quad (15)$$

and corresponds to a spontaneous decay of the meson. The interaction of mesons with the light particles can then be adjusted to give the right decay periods for the radioactive elements.

A consequence of the assumption (15) is that a free meson, although an elementary particle, is not a stable one. After a period of about 10^{-8} seconds it spontaneously decays into an electron and a neutrino. This introduces a new feature into our picture of an elementary particle. The instability of the meson, and the prediction of the special theory of relativity that clocks in motion go slower can both be proved from an analysis of experiments on cosmic radiation. In this connection it may be mentioned that there is some evidence, though it is not conclusive, that a neutral particle of the meson mass is also found in cosmic radiation.

Relativistic quantum mechanics predicts that a particle of *exactly* the proton mass but opposite charge should exist in nature and be capable of being created in pairs with a proton. A negative proton has not yet been detected. It can be shown, however, that the probability of its being created with a proton by the materialization of a quantum of radiation is at least a million times smaller than the corresponding process for an electron. In this connection may be mentioned the idea put forward by the present author that the heavy particles can exist in states of all integral charge, positive or negative, with different rest masses, the proton and neutron being the states with lowest energy. The purpose of this assumption is to reduce the scattering of charged mesons *at low energies*, whereas, as Fierz has shown by an extension of the classical theories mentioned earlier, radiation reaction reduces the scattering of charged mesons at higher energies. A consequence of this assumption is that a proton of double charge, as also of negative charge but mass higher than that of the proton, should on rare occasions be detectable as free particles. There is as yet no experimental evidence of their existence.

To sum up, in addition to the two elementary particles, the electron and the proton, which have been known for a long time, the existence of several others has now been definitely established by experiment. Thes, particles are 'fundamental' or 'elementary' in the sense that all structures in nature are built out of them, while they themselves cannot be considered as built up of more fundamental entities. On the other hand, they do not preserve their identity immutably for all time, but on the contrary, take part in a considerable number of transformations in which the number of particles of any given type may change, the only quantities which are conserved in all

these reactions being energy, momentum, angular momentum and charge. All the elementary particles whose existence has been definitely established are either uncharged or have a charge $\pm e$. The charge e is, therefore, a fundamental constant of nature like the velocity of light c or Planck's constant h. As is well known, any one of these constants can be expressed in terms of the two others, the pure number $e^2/\hbar c$ having the experimentally determined value of about 1/137. In accordance with our present attitude we should expect that a complete theory of physics will inevitably explain the relation between these three constants. On the other hand, the masses of the electron, the meson, the proton and neutron have a complicated ratio to each other, while a light quantum has no rest mass. Nor has it yet been established that all mesons have the identical rest mass. Although, therefore, the present view is not to regard the rest masses of the elementary particles as of field origin, but rather as definite mechanical constants associated with each type of particle, nevertheless, these masses must be regarded as less fundamental constants of nature than the charge e, the velocity of light c and Planck's constant h. We should expect that a complete theory of physics will in the future explain their relative ratios possibly in terms of a more fundamental and hitherto undiscovered constant of nature having the dimensions of a mass or a length.

SECTION OF CHEMISTRY

President :—S. S. Joshi, D.Sc.

Presidential Address

(Received after the Session)

SOME ASPECTS OF MICELLAR AND MOLECULAR ACTION

Whilst induction from large-scale, objective particulars to generalizations based on a conceptional mechanism, has been the main track of scientific progress, the opposite has happened more than occasionally and with outstanding consequences. The postulation, for instance, of the atomic and molecular action as the ultimate source of all material changes and, in fact, of the existence of these entities preceded by half a century the discovery of colloids, although their characteristic operative units, the micella, are nearer experience in respect of both their dimensions and especially the extreme manifoldness of occurrence in natural phenomena, the 'living world' and industrial practice. The stability of a colloid depends largely on repulsion due to the similarity of micellar charges. A diminution of this last or rather of the corresponding electro-kinetic potential constitutes one of the chief determinants of coagulation. Its actual time-rate, however, is amenable to control by an appropriate selection of such factors as the nature of the medium, the strength of the coagulant—even its manner of addition and the presence in but small amounts of certain accessory substances called sensitizers, the protecting agents, etc.; the last-named serve to retard coagulation.

§2. Coagulation and Protection.

It is remarkable that practically all the important protecting agents known so far are themselves colloidal. The most potent of these are of the *hydrophyllic* type, characterized by a marked influence in lowering the interfacial tension, and their consequential concentration at the interface. In developed cases of this action, there might result formation of definite skins of the protecting substance, enclosing the micella and thus reducing the coagulative effect of the added electrolyte. A review of the literature shows that the position of our knowledge is much uncertain as regards (i) the potency of a given proportion of the protector in relation to the specific nature of the colloid and of the coagulator employed, (ii) distribution of the protecting substance between the dispersed phase and the continuous

medium, and (iii) the nature of the forces involved in the protection phenomena [1, 2, 3, 4, 8].

Quantitative studies in respect of (ii) are fundamental to our understanding of (iii) and involve determination of adsorption of the protecting substance by the colloid. The experimental difficulties in these measurements are great and the interpretation of results far from simple, especially when a hydrophyllic colloid is used as a protector. It is not surprising, therefore, that sufficient data are not available in the literature about (ii). Some results in this line, particularly, on the protection of colloidal arsenious sulphide by gelatin, starch and by sodium oleate solutions showed that, subject to certain simple and plausible assumptions, the adsorption of the protecting agent by a given amount of the sol increased sensibly *linearly* with its concentration [5]. Freundlich and Löning [6] found, for instance, that except when saturation is reached the protecting power of saponin increased regularly with its concentration. It is to be anticipated, therefore, that corresponding to the complete coagulation of a sol, the amount of the electrolyte required should increase with that of the protector. Implied in the definition of the term 'protective power' on either the 'gold' or 'rubin' number basis [2], the above deduction was found to be in agreement with measurements of adsorption from variously concentrated solutions of barium chloride and hydrochloric acid with different protecting agents. Results were, however, strikingly different with ferric chloride [5]. Here although the amount of the protector used, *viz.*, gelatin, was varied over a wide range, about fifty-fold, the adsorption of the ferric ions corresponding to the completion of coagulation was sensibly constant. Furthermore, the adsorption of the coagulant for a number of protected sols was not sensibly greater than that for unprotected sols. It is not possible, therefore, to envisage protection in terms of a single, general mechanism. It is of considerable interest to observe in this connection that the order of the magnitude of adsorption of ferric chloride was much greater than that for other electrolytes. Analogous to the protective action is the rôle of the so-called 'emulsifiers' which stabilize the dispersion of one immiscible liquid into another. Measurements of the viscosity of a number of these emulsions have shown that the Einstein equation deduced in the first instance for suspensions is applicable to their behaviour [7, 8]. Joga Rao has made an interesting observation that the protective power of a substance depends sensibly on the manner of its introduction [9]. The general utility of this result is obvious, *e.g.* in the standardization of the detergent powers of soaps [2].

§3. Kinetics of Coagulation and its Measurement.

Perhaps the most powerful impetus to the study of the coagulation process was given by the theoretical work of Smolu-

chowski [10] suggested by Zsigmondy's [11] results. Coagulation was regarded mainly as a progressive union of both the initially discharged micella and of the products of subsequent coalescence; it is, therefore, an autocatalytic, macromolecular analogue of a 'second order reaction'. Besides the general equation (*vide infra*, §6, p. 63)

$$\beta = \frac{2\pi RT}{3N\eta} \cdot \frac{l}{r} \qquad \text{(i)}$$

deduced by Smoluchowski, the predictions of the theory have been examined chiefly in respect of two particular consequences represented by

$$\Sigma n_t = n_0/(1+\beta t) \qquad \text{(ii)}$$

$$\beta = 1/t\,[\sqrt{n_0/n_t}-1] \qquad \text{(iii)}$$

where Σn_t and n_t denote respectively the total number of particles and the primaries at time t; n_0 is the number of primaries at $t = 0$; β = velocity constant. It is known that although valid substantially for '*rapid*' coagulations, the theory practically breaks down in the so-called '*slow*' region, despite the introduction by Smoluchowski of ξ, a variable probability factor in respect of the initial incomplete micellar discharge, which is the main distinctive feature of a '*slow*' coagulation. The findings of a number of investigators (including especially J. N. Mukherjee [13a] who had commenced work in this field earlier than the publication of Smoluchowski's memoir) show that, in general, β, the velocity coefficient, diminishes appreciably with the coagulation-time in the '*slow*' region [13b, 14, 15, 16]. By far the majority of workers have found that employing equation (ii), Smoluchowski's theory is applicable only during the initial stages of a '*slow*' coagulation [13, 14, 15, 16]. On the contrary, using equation (iii), the results of a number of *slow* coagulation measurements carried out at Benares have shown just the opposite, that is, the deviation from theory occurs more during the initial than during the subsequent stages [17, 18, 19, 21]. This is also deducible using equation (iii) from the results for the gold sol coagulation in the *slow* region, as reported by Anderson [20] (who, however, does not point this out). Equations (i) and (ii) being but deductions from the same theory, the above anomaly between the two sets of results, *not noticed hitherto*, is untenable. This may be ascribed to the circumstance that the application of equations (i) and (ii) to experimental results involves a tacit and arbitrary assumption, *viz.*, that changes in any of the properties employed in order to follow the progress of coagulation, such as the opacity, the viscosity, etc., are measures, or, at any rate, single valued and continuously variable functions of the quantities Σn and n_t in equations (ii) and (iii), for which there is no *a priori* justification [19].

The actual measure of agreement, however, between the experimental results and predictions of Smoluchowski's theory at any rate in the region of the *rapid* coagulation suggests that the above-mentioned theoretical deficiency is but a landmark, less a barrier, in our progressive envisagement of the coagulation mechanism. It would also appear that perhaps the most profitable way of developing the subject is to follow the progress of a coagulation, especially in the *slow* region by as many independent methods as possible. The programme of work at Benares in this line has included methods based on the estimation of the amount of unfiltrable coagulum at a given stage[17, 18, 21]; changes in the surface tension,[19] opacity *and the independently observed* transparency[22, 23, 24, 25, 26, 27, 28, 29]; viscosity by both the well-known transpiration measurements[30, 31, 32, 33, 34, 35, 36, 37] and the more recent rotating cylinder method[38]; and refractivity[39, 40, 41, 42, 43, 44, 45, 46]. The use of the last-mentioned property, *not employed hitherto in the field of coagulation kinetics*, has revealed a simple and sensitive detector, wherewith changes may be observed with a satisfactory speed and precision, without disturbing the inner micellar equilibrium, which is a general characteristic of optical methods.

An outstanding result of these measurements has been the demonstration that a marked limitation obtains in the use of the viscosity and transparency changes as measures of coagulation. Smoluchowski[47] argues that since the micellar charge diminishes during coagulation, a like change in the corresponding viscosity should result. Dhar and co-workers[48] postulate, on the other hand, that other things being identical, a reduction of charge would increase the micellar hydration; as a consequence, the viscosity would increase during coagulation. While this appears to be the general view of colloid chemists, *numerous cases have been established during work at Benares in which the viscosity has shown an over-all diminution*[32, 33] *during coagulation*, particularly when the coagulations were *slow*. A similar anti-normal result has been observed, it is believed for the first time, in the case of another typical colloid sensitive property, *viz.*, the *opacity*. Its use as an index of coagulation has been in vogue ever since this phenomenon came to be studied even qualitatively. Now it has been observed that in a number of *slow* coagulations of colloid manganese dioxide, the opacity of the system towards both the white light and that due to a narrow band showed a sensible *diminution*[24, 26]. These apparently anomalous results in respect of both viscosity and opacity were also noticed, though to a smaller extent in changes often leading to coagulation, under exposure to high frequency oscillations[29] (*cf.* also 49 and 50).

It is of interest to refer at this stage to the rather remarkable behaviour of mercury chloride used as a coagulant[23, 25, 52]. Contrasted with its almost entirely non-electrolytic character

as illustrated, for example, by its very low electrical conductivity in both dissolved and fused states, its solubility in organic solvents, and the Raman spectrum, mercury chloride shows a surprisingly high coagulating power; in a few cases, this is higher than even some of the typical bi-valent coagulants, such as barium chloride [52]. Now when arsenious sulphide sol was coagulated by mercury chloride, there was produced but a small change in the initial viscosity and transparency of the system, despite the addition, in appreciable amounts, of the coagulant, which produces sensible flocculation in but moderate periods of time [23]. When, however, mercury chloride was mixed with small quantities of other coagulators such as potassium chloride and cadmium chloride, both the above-mentioned properties showed their usual variation, *i.e.* increase during coagulation [23]. It is suggested that the viscosity and transparency of a colloid do not depend entirely on the familiar hydrodynamical and optical constants distinctive of the medium and the micella; what may be designated as the body or the structural effect of the colloid as a whole, especially the behaviour of the semi-mobile, micellar conglomerate tending to be interlaced during coagulation, is presumably an additional and not a negligible factor.

It is necessary to emphasize that the above failure of the two typical colloid sensitive properties to change uniformly under all types of coagulation has its extension in the case of such simpler micellar changes as '*thermo-ageing*'. Thus, for instance, whilst the refractivity showed but a small increase consequent on 'thermo-ageing', in all the 42 cases examined [53], changes in viscosity and opacity before and after 'thermo-ageing' were not always in the same direction [54]. The simplest of colloid changes is seen, therefore, to be markedly complex compared with an ordinary type of chemical reactions; the extent of the latter, in general, is measured by the corresponding change in the magnitude of a single variable. Whilst it is extremely unlikely that there can be one parameter defining completely the progress of a micellar change, an expression for the analogue of the 'active mass', familiar in molecular changes, in at any rate empirical terms, represents at present the principal need in the field of coagulation kinetics.

§4. The 'Wall Effect' in Coagulation.

A rather striking indication of the '*heterogeneity*' of a colloid reaction was afforded by the finding that the well-known auto-coagulability of colloidal manganese dioxide increased considerably when small amounts of such substances as filter and parchment paper, celluloid, animal charcoal, unglazed porcelain, all carefully cleaned before use, were introduced in the sol [55, 56]. Evidence showing that the walls of the containing vessel cannot be regarded as but an inert component of the system was afforded

by the observation that the characteristic precipitation of the above sol on the parchment paper during dialysis was reduced very markedly by applying a negative potential of about 200 volts to the dialyzing septum [55, 56].

It is instructive to emphasize at this stage that in Smoluchowski's theory [10] and also in the one due to Freundlich [12] (which in certain respects is more comprehensive than Smoluchowski's but limited in the range of its quantitative applicability) the coagulation is assumed tacitly to be an entirely *homogeneous* reaction. This appeared to be unwarranted in view of the findings of numerous investigators that even in gases which represent comparatively the simplest media of chemical changes, heterogeneity of reaction due to 'wall catalysis' is widely occurrent.

Subsequent work [21] has shown that this 'wall effect' is not restricted to the charged state of the container; it may well be a general characteristic of colloid reactions. This has been now investigated in the coagulation of a number of colloids by different electrolytes under a wide range of conditions of temperature, and coagulator concentration. The effect has been studied by following the course of any given coagulation, (*a*) first with the normal wall area of the containing vessel, (*b*) when this was increased about four-fold by introducing smooth glass beads of known size, and (*c*) when the containing walls and the beads were paraffinned. A number of these coagulations were found to be autocatalytic under (*a*) as judged from the rise in β, and the S-shape of the corresponding coagulation-time curves. The coagulation rate increased and autocatalysis diminished markedly under (*b*). The opposite was observed in (*c*). The 'wall effect' is specific as to the nature of the sol and its state of protection; it is maximum during the early stages of coagulation.

It is to be anticipated from the present theories of the general mechanism of heterogeneous catalysis in molecular reactions and from the generality of experimental results, that the 'wall effect' would be greater, the lower the temperature of the coagulating system. The unpublished results of Roy Choudhari at Benares are in agreement with this deduction. The accumulation of such data with variously covered surfaces as in the suggestive experiments of Norrish and others [57, 58] might give valuable information in correlating coagulation with the polarity or otherwise of the molecules on the walls.

The above results have revealed the existence of a hitherto unrecognized and possibly general determinant of the coagulation process. They also show that the use of the wall material in divided form is of value in elucidating the intrinsic course of a given coagulation, as '*rapid*' or '*slow*' in terms of Smoluchowski's theory [10]. To quote one typical series of results in the coagulations of ferric hydroxide sol by potassium chloride [21]: In the reaction with the normal wall area, about 87% of the sol was

coagulated in the first 60 minutes; the corresponding coagulation-time curve was markedly S-shaped and the velocity coefficient β *increased* about ten-fold. This tendency became more pronounced during coagulations in the paraffinned vessels. In ordinary glass containers under increased wall area, however, it disappeared, other conditions remaining the same. Furthermore, during the above period the percentage coagulation remained about the same as before, but what is more significant, β remained steady and the bimolecular constant increased with the coagulation time. In terms of Smoluchowski's theory this is indicative of a '*rapid*' coagulation. Similar results of a general character were observed in coagulations, which when unmasked of their apparent autocatalysis by use of the above device were seen to belong to the '*slow*' region of coagulation as judged from the observed variation with time of β and of the corresponding bimolecular constant. In the light of these results, it is of interest to enquire whether a mere change of magnitude in the rate of coagulation, under the '*wall effect*', can change the intrinsic type of a coagulation, *i.e.* convert a '*slow*' change into a '*rapid*' one and *vice versa*. This is unlikely since the main characteristic of the '*rapid*' coagulation is that the particles are completely discharged; whereas in the '*slow*' region, the discharge is only partial. It follows, therefore, that like such factors as change of viscosity and of the temperature, the 'wall effect' might alter the absolute velocity but not the characteristic *type* of coagulation.

In discussing the limitations of the applicability of Smoluchowski's theory in the *slow* region [10], it has been supposed by some workers [2, 59, 60, 61, 62 63] that the deviations might be due to an autocatalytic nature of the coagulation process in the *slow* region. It may be recalled that the supposition which is fundamental to Smoluchowski's theory [10], *viz.*, that a coagulation is a multi-stage change in which products of earlier coalescence participate, makes both the '*rapid*' and '*slow*' coagulation autocatalytic; this is fully considered and allowed for in the deduction of Smoluchowski's equations for the kinetics of coagulation. What may be called the extra autocatalysis (as indicated by the rise in β, by the occurrence of S-shaped coagulation-time curves and by the fact that the familiar equation for an autocatalytic reaction applies, at any rate, in some cases) is but a secondary phenomenon which adds on to the main course of coagulation under certain conditions; its elimination, without affecting the fundamental type of the change, is necessary before data for a given coagulation can be employed for the application of Smoluchowski's [10] or any other theory [12]. To this end, the use of wall material in divided form or its equivalent would appear to be a simple means [21].

§5. 'Zonal effect' in the Slow Region of Coagulation.

Smoluchowski's [10] and other theories [12] of the kinetics of coagulation have tacitly assumed that the process is essentially a *time-continuous*, micellar coalescence. The earliest indication [30] of a limitation of this supposition, at any rate in the slow region, was afforded by the viscosity-time curves (Fig. 1), for changes due to progressively decreased values of C, the coagulator concentration. At first, the viscosity showed the familiar rise which set in from the very commencement of the reaction; with lower values of C, the coagulation-time curves showed a slow, S-shaped rise, which was preceded usually, if not invariably, by an initial fall of viscosity (*cf.* curves 1, 2, 3);

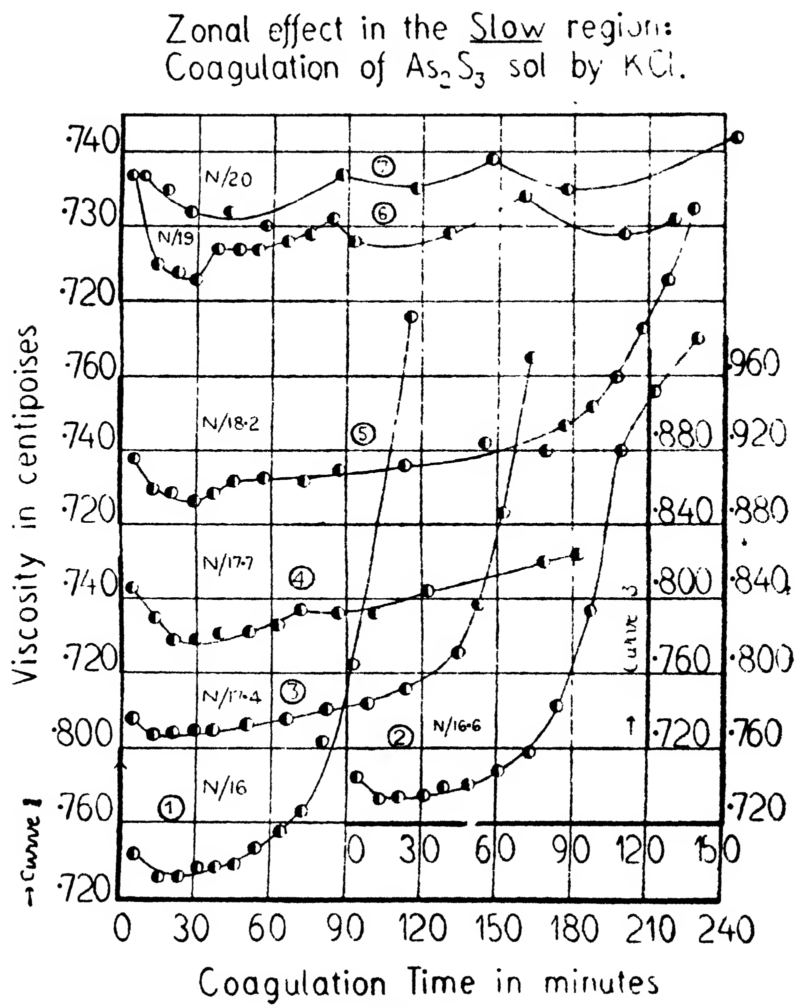

Fig. 1.

this became more pronounced with decreasing C (*cf.* curves 4, 5); with C smaller still, after an increase to a limited value, the viscosity diminished to a minimum, which was followed by a rise and a subsequent fall and so on; the entire course of coagulation was characterized by a series of '*zones*' or discontinuities in the time-variation of the corresponding viscosity of the system (*cf.* curves 6, 7).

Presumably, the viscosity of a coagulating colloid is determined by more than one variable, such as the number, the average size and shape of the micella, the state of their hydration and electrical charge; a loose-grained and mobile inter-micellar structure is responsible for the macroscopic or the body-properties of the system; the last-mentioned possibility was suggested by considerations independent of viscosity variations. There is no reason to suppose that any of these factors would vary continuously with the coagulation-time; their time-variations at a given stage might not even obtain in the same sense. For instance, (due partly to an inertial effect, the operative units being of appreciable dimensions and complexity), a proportion of the coagulating particles having coalesced to produce a micellar conglomerate of a size and structure not compatible with the requirements of stability, a reverse change might set in with a corresponding effect on the viscosity of the system. It is to be anticipated, therefore, that the operation of such a process over a prolonged time, which is a marked characteristic of a *slow* coagulation, will produce discontinuities or the '*zonal effect*' in the time-variation of viscosity or similarly conditioned properties, as has been actually noticed.

As regards the observation made previously of an initial fall of viscosity at reduced concentrations of the coagulator, *i.e.* in the *slow* region and when the main reaction tends to be *zonal*, the following finding of a number of workers may be recalled[64, 65, 48]: When to a given amount of a sol, increasing amounts of the coagulant are added and the corresponding change of viscosity produced within a given time is determined, it is found that first the viscosity diminishes to a minimum and then rises at larger concentrations of the coagulant. This initial fall of viscosity is considered by some workers to be due to a reduction of the micellar size produced by the osmotic action of the added coagulant; others have ascribed it to adsorption of ions carrying a similar charge. Whilst either, or what is more likely, both of these factors may be operative, the (unpublished) work at Benares of Subbaiyya, Raghavan and Chatterji shows that the above phenomenon of an initial reduction of viscosity is not confined to direct electrolytic coagulations; it has been observed in coagulations induced by such non-material means as electrical oscillations under suitable conditions[29, 49, 50, 51].

This occurrence of a reduction of viscosity, observed as an initial phase of numerous *slow* coagulations, shows that it is not incompatible with an over-all micellar instabilization and may well be regarded as a part of the direct and reverse changes of viscosity indicative of the *zonal* nature of coagulation in the *slow* region irrespective of the nature of the coagulative agency. Reference might be made at this stage to observations by Holker [67] of remarkable periodic discontinuities in the opacity variations during the precipitation of calcium oxalate, which has been ascribed by him to non-uniform changes in the particle size.

Next to viscosity, observation of a change of relative opacity has had perhaps the widest usage as a measure of coagu-

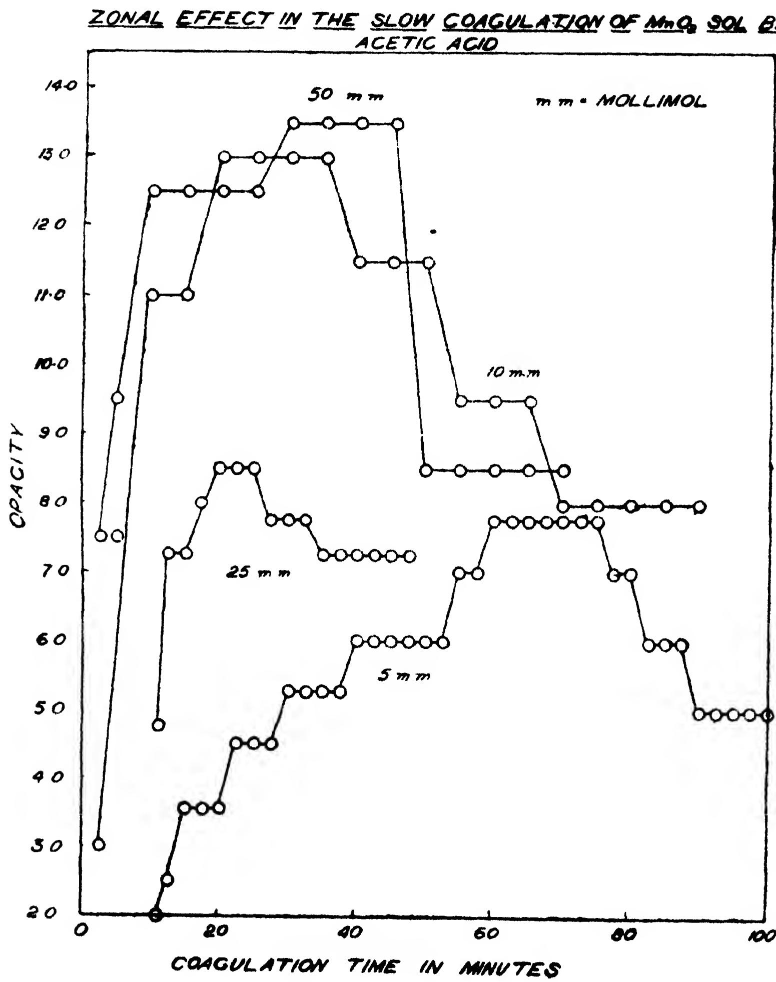

FIG. 2.

lation. Despite considerable work on the subject, the position so far of a precise expression for the opacity of a coagulating sol in terms of the significant optical and micellar constants of the system is at best only qualitative. A careful consideration, however, of the data for this quantity [22, 24, 25, 26, 28, 29], as well as for the independently determined transparency (*cf.* Fig. 2), both for white light and different bands in the visible spectrum, and for the simpler and relatively more basic property, *viz.*, the refractivity [37, 39, 40, 41, 42, 43, 44, 45, 46], *cf.* Fig. 3, have now afforded

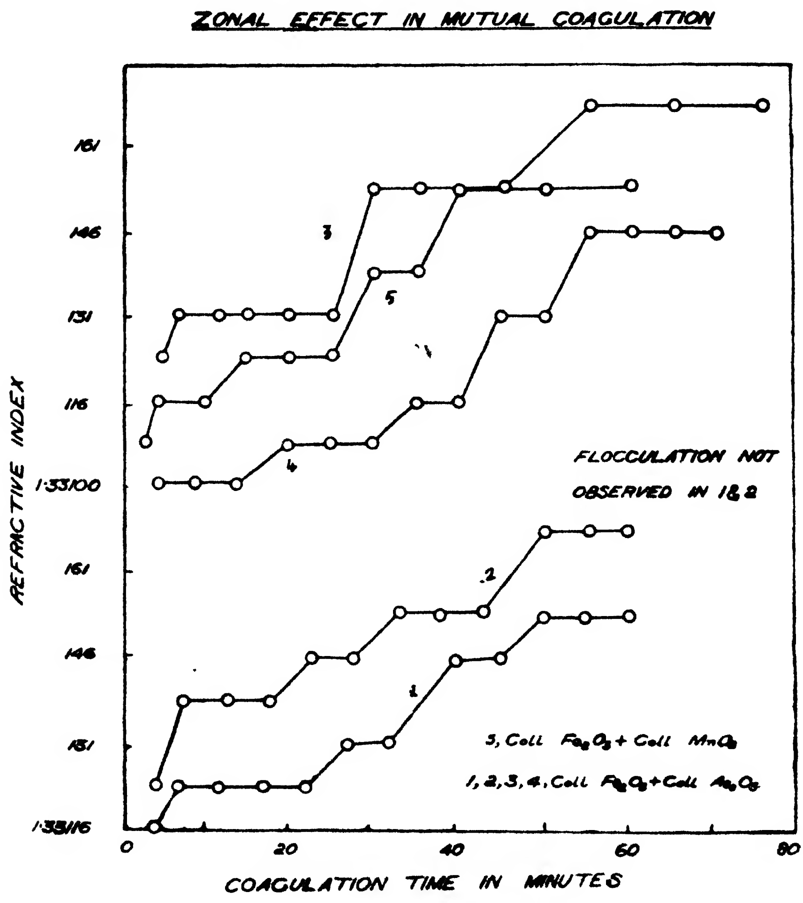

Fig. 3.

detailed support to the deduction made previously, from results for the viscosity variations (*cf.* Fig. 1), as regards the *zonal* character of a coagulation in the *slow* region.

Numerous cases have been observed in which, contrary to the general view held by colloid chemists, the transparency of a sol *decreased* during coagulation (*cf.* Fig. 2). Similarly,

whilst in the majority of cases refractivity has been found to decrease, the occurrence of the opposite effect is by no means rare (*cf.* Fig. 3). *It must be emphasized, however, that independent of whether any of the above properties changes during coagulation normally or otherwise, the 'zonal' or the discontinuous nature of the corresponding coagulation-time curve has been observed to be the constant characteristic in the slow region* (*cf.* Figs. 1, 2, 3).

Detailed work has been in progress for some considerable time on the effects of the exposure of colloids to alternating electrical fields of low frequencies and those due to continuous or stationary potentials, to the high frequency oscillations obtained from disruptive condenser discharges and to fairly well-defined bands in the radio frequency range. It is found that this agency has an appreciable power in both initiating and altering the rates of coagulation [66] and (such allied changes as) gelation [46] and '*ageing*' already in progress. The chief interesting feature of these results is that coagulations followed by observations of the time-variations of the viscosity, the transparency and the refractivity of the system show the '*zonal effect*', *which becomes more pronounced the slower the change in the case of electrolytic and mutual coagulations.*

A consideration of these, especially the transparency-time (Fig. 1) and refractivity-time curves (Fig. 3), shows the existence of stages, during which either of the above-mentioned properties, in so far as its change is an index of the corresponding degree of coagulation, remains almost stationary or, at any rate, shows a sensibly lower rate of change than during the preceding and succeeding *zones*. It is instructive to consider coagulation in terms of (i) changes in the inter-micellar or continuous medium, and (ii) those affecting more directly the micella. Primarily, the introduction of a coagulant in small amounts, as in the *slow* region, influences (i); this then disturbs the osmotic equilibrium between the micellar contents and the continuous medium, leading to ionic and molecular adsorption, or altering the pre-existing adsorption on the micella and affecting their stability. If, now, the plausible assumption is made that a direct micellar reaction in (ii) and its antecedent implied in (i) possess different rates of change and that the former, *i.e.* (ii), develops only after a certain stage in (i) has been attained, the existence of the relatively stationary states as observed is conceivable. Detailed data distinctive of a wide variety of conditions in regard to the dependence of the nature and the frequency of the occurrence of these zones would be obviously of fundamental importance to a more complete elucidation of the coagulation mechanism. It is interesting, for example, to point out that if either or both the number and duration of the stationary states be comparatively more predominant during a given stage, such as, at the commencement of the change, an S-shaped coagulation-time curve suggestive of autocatalysis would be the result.

§6. A proposed General Theory of the Kinetics of Coagulation.

Zsigmondy [11] had observed that the increase in the velocity of coagulation with that in the electrolyte concentration reaches a limiting value, which is independent of the strength and, to an appreciable extent, of the nature of the coagulator. Smoluchowski's classical theory [10], based chiefly on these and allied results of Zsigmondy [11], assumes that the addition of the electrolyte neutralizes completely the like electrical charges on the micella and that every collision between such micella produces an irreversible coalescence. The following expression for the rate of coagulation is one of the chief results of Smoluchowski's theory:

$$\beta = \frac{2\pi RT}{3N\eta} \cdot \frac{l}{r} \quad \ldots \quad \ldots \quad \ldots \quad \text{(i)}$$

l denotes the distance within which two particles must approach for the collision to become effective; r is the average radius of the micella, assumed to be spherical; η is the viscosity.

The equation (i) predicts the above-mentioned result of Zsigmondy [11] observed in the *rapid region, i.e.* due to high concentrations of the coagulator. The influence of temperature on the rate of coagulation is determined by the factor $\frac{T}{\eta}$. The results of Lachs and Goldberg [68] are in agreement with this deduction.

The above equation breaks down in the *slow* region of coagulation; β diminishes with the coagulation time. Smoluchowski [10] considered that during the *slow* coagulations, the micellar charges are but incompletely neutralized; ζ, the probability of coalescence in a given collision of such particles is less than unity in the *slow region*; presumably, ζ depends upon the coagulator concentration. Since β diminishes during a *slow* coagulation, it would appear that ζ diminishes in a like manner, if the other factors are unaltered. Mukherjee and Papaconstatinou [14] considered that ζ might depend upon the ionic adsorption. It is of interest to observe [17, 18] that the influence of temperature on β in the *slow* region departs from that indicated by Smoluchowski's theory and is analogous to that on the ionic adsorbability ζ.

A much simpler treatment of the coagulation-kinetics is afforded by considering that ionic adsorption is the chief determinant of the micellar charge, and consequently of the stability of the colloid as a whole; it is to be anticipated, therefore, that this quantity would also define the corresponding rate of coagulation. In order to give a quantitative form to this idea, it is assumed that x the amount of micellar adsorption in a colloid subjected to electrolytic coagulation is given by the following

equation, which is a modified form of Freundlich's adsorption isotherm,

$$x = \alpha m c'^{\frac{\epsilon}{n}} \quad \ldots \quad \ldots \quad \ldots \quad \text{(iv)}$$

where m is the amount of the colloid (or perhaps more appropriately the micellar surface); c' is the inter-micellar concentration of the coagulating electrolyte; α and n are constants; ϵ denotes the micellar charge. The rate of coagulation on the above hypothesis is, therefore, given by

$$k = \frac{a\alpha m}{\eta} \, . \, c'^{\frac{\epsilon}{n}} \quad \ldots \quad \ldots \quad \ldots \quad \text{(v)}$$

where a is a constant; η is the viscosity of the medium. If the initial concentration of the electrolyte be denoted by c, we have

$$k = \frac{a\alpha m}{\eta} \, . \, [c - \Delta c]^{\frac{\epsilon}{n}} \quad \ldots \quad \ldots \quad \text{(vi)}$$

where Δc is the change in c' due to micellar adsorption.

$$k = \frac{a\alpha m}{\eta} \, . \, c^{\frac{\epsilon}{n}} \, , \left(1 - \frac{\Delta c}{c}\right)^{\frac{\epsilon}{n}} \quad \ldots \quad \ldots \quad \text{(vii)}$$

Expanding the quantity in the bracket, and since n exceeds unity and ϵ is small, we get to a sufficient approximation

$$k = \frac{a\alpha m}{\eta} \, . \, c^{\frac{\epsilon}{n}} \left[1 - \left(\frac{\Delta c}{c}\right)\frac{\epsilon}{n}\right] \quad \ldots \quad \ldots \quad \text{(viii)}$$

From considerations mentioned above regarding ϵ and n, and also when the fraction $\frac{\Delta c}{c}$ is sufficiently small, so that the quantity inside the bracket is practically unity, we get

$$k = \frac{a\alpha m}{\eta} \, . \, c^{\frac{\epsilon}{n}} \quad \ldots \quad \ldots \quad \ldots \quad \text{(ix)}$$

Further, when the amount of the electrolyte added is large, ϵ is negligibly small and therefore $c^{\frac{\epsilon}{n}}$ in (ix) is reduced to one, and we get

$$k = \frac{a\alpha m}{\eta} \quad \ldots \quad \ldots \quad \ldots \quad \text{(x)}$$

The general finding that the rate of coagulation in the *rapid region* is independent of the concentration of the coagulator (and which has been the main item in the verification of Smoluchowski's theory) is brought out by equation (x). The dependence of the rate on m in (x) and, therefore, on the sol concentration as suggested by (x) is extremely likely. The equation (x) further predicts that, being proportional to α, one of the constants in the *modified* adsorption formula, the coagulation rate in the *rapid* region would depend also upon the specific nature both of the colloid and of the electrolyte, a circumstance practically ignored in Smoluchowski's theory. In this connection it might be pointed out that the work of Zsigmondy [11] on the gold sol, of Lüers [69] using congorubin red and of others has shown that in the *rapid* region the minimum time of coagulation (which gives a measure of the coagulation rate) showed a sensible change when solutions of different coagulators were employed. More detailed and accurate data would appear to be necessary to examine the last deduction made here. It is obvious that the ϵ term in (ix) stands for the numerical magnitude of the micellar charge after the addition of the electrolyte. It is known from the experiments of Lüers [69] that when specially high concentrations of the coagulator are used, the charge on the particles is reversed in sign and is no longer negligible. The simplification leading to (x) is no longer permissible, and it is to be anticipated from (ix) that the coagulation rate would increase by increasing c *beyond the rapid region*. This consequence from the present theory has been fulfilled by the work of Lüers [69].

It is seen that practically all the main results in regard to the *rapid* coagulations, some of which are in accord with Smoluchowski's theory, are deducible from that now proposed. The theory further treats the *rapid* and *slow* regions of coagulations as particular cases of a unitary coagulation mechanism embodied in (i)–(ix). A general characteristic of coagulations in the *slow* region is that the value of ϵ is high at the start of the coagulation. Equation (ix) shows that the coagulation rate increases rapidly by increasing c, the electrolyte concentration (in fact exponentially, in case ϵ and η do not change sensibly in a given concentration range); this agrees very well with the experimental results of numerous workers in this field, and in fact embodies the empirical expression proposed by Freundlich [2, 12], *viz.*,

$$k \propto c^p \qquad \ldots \quad \ldots \quad \ldots \qquad \text{(xi)}$$

where p is a constant. Instead of k, considering T the time to produce a given stage of coagulation, it follows from (xi) that

$$\frac{1}{k} = T = \frac{1}{c^p}$$

Considering any two concentrations c_1 and c_2,

$$p = \frac{\log T_1 - \log T_2}{\log c_2 - \log c_1} \quad \ldots \quad \ldots \quad \text{(xii)}$$

This is the well-known empirical equation due to Paine [70]; it is perhaps the widest observed quantitative result in the region of *slow* coagulation. A review of the literature in this line shows, however, that p is not constant, but varies over a limited range [2, 17, 18]. It increases by diminishing the concentration of the coagulating electrolyte [2, 17, 18]. It is now proposed to shew that Paine's equation, as also the conditions of its applicability are derivable from equation (ix).

Let c_1 and c_2 denote the coagulator concentrations in the continuous medium; if ϵ and $\epsilon_1 + x$ are the corresponding micellar charges and change of η with c be assumed to be negligible, writing A for $\frac{\eta}{a\alpha m}$, we get

$$T_1 = A \Big/ c_1^{\frac{\epsilon}{n}} \quad \ldots \quad \ldots \quad \ldots \quad \text{(xiii)}$$

$$T_2 = A / c_2^{\frac{\epsilon + x}{n}} \quad \ldots \quad \ldots \quad \ldots \quad \text{(xiv)}$$

$$\frac{e}{n} = \frac{\log T_1 - \log T_2}{\log c_2 - \log c_1} - \frac{\frac{x}{n} \log c_2}{\log c_2 - \log c_1} \quad \ldots \quad \text{(xv)}$$

If now x is zero, *i.e.* micellar charges at the two concentrations c_1 and c_2 are sensibly the same, the last term in (xv) disappears, and we get Paine's equation by identifying p with $\frac{\epsilon}{n}$.

It is well known that there is a general parallelism between ϵ and the stability of the colloid, which is greater the lower the value of c. The stability is in fact a maximum at the so-called Bodländer's limit which denotes the least value of c necessary to produce a just preceptible coagulation. It is reasonable, therefore, to conclude that ϵ increases as c diminishes. Since $P = \frac{\epsilon}{n}$, it follows that P should increase as c is diminished. This is in agreement with the available results. Now, ϵ vanishes in the *rapid* region, p is, therefore, zero; this gives from (xv), $T_1 = T_2$, that is, as seen already, in the *rapid* region, the time to produce a given state of coagulation is a constant independent of the coagulator concentration.

The micellar behaviour is mainly determined by the electrokinetic potential, of which in the generality of cases ϵ is an adequate measure. The rôle of such of the associated factors as the size and constitution of the micella is of considerable importance. The former determines the capacity in regard to ϵ;

the latter depends upon the distribution of ions and molecules on the micellar surfaces and in their neighbourhood. Either or both these factors might vary in a certain sense up to a limit determined by the micellar stability compatible with a given value for ϵ. It follows, therefore, that a micellar change, coagulative or of other type, might proceed to a certain extent, during which ϵ would remain sensibly constant; its further progress would involve a new value of ϵ, which remaining constant over a limited range of conditions, might alter to another critical value, and so on. There is some considerable evidence in the literature indicating such discontinuous change in ϵ, as, for example, during prolonged dialysis [101]. Such a change in ϵ would make the corresponding progress of coagulation time-discontinuous or *zonal*, since the significant time-rate of the change as given by (ix) would not be uniform.

Now since $P = \frac{\epsilon}{n}$, a discontinuous variation in ϵ as the coagulator concentration is changed, would lead to a like change in P when investigated over a large range of concentrations of the coagulator [17, 18]. This is in accord with the unpublished work of Godbole at Benares.

§7. Some Periodic Phenomena under Electric Discharge.

Studies of the '*zonal effect*' (§5), observed in *slow* coagulations, have suggested that it may be affine with the numerous periodic type of changes [72], such as the adsorption-desorption phenomena shown by the 'cold worked' metals [73]; their periodic dissolution in acids under certain conditions, and like effects in a number of electrochemical reactions observed particularly with electrode materials capable of assuming the passive state [73, 74, 75, 76]; the pulsating catalysis of hydrogen peroxide by mercury and other substances [77, 78, 79]; the intermittent luminosity of phosphorus [80]; and periodic phenomena in enzyme action and colloid catalysis [79]. Along with these perhaps may be classified the production of rhythmic structures such as the Leisegang rings and the so-called pulsating surfaces investigated by Quincke [82, 83]. In the interpretation of the results of practically all these types of action by numerous investigators it has been found advantageous to postulate the rôle of a metastable phase in the form of fine-grained nuclei in the reaction space (as, for instance, in Lord Rayleigh's theory of the glow of phosphorus) or an unstable film, or activated surfaces such as the electrodes or the walls of the container vessel. It is just these factors which are either inferred from, or found necessary to presume, as predisposing the '*zonal effect*' (§5) during the *slow* coagulation as revealed by a study of their time-variation, using independent methods and produced by both electrolytic and apparently non-material means. An extension of analogy

between these predominantly micellar and molecular systems is afforded by the observation of the '*wall effect*' and its enhancement under electrical influence, in numerous coagulations (§4).

An interesting reaction, suggestive of a possible rôle of the above-mentioned factor, was observed in the 'ageing' effect shown by bromine vapour subjected to ionization by collision in the annular space of a Siemens' type ozonizer under fields due to alternating electrical potentials of commercial frequency [84]. This yields the so-called silent discharge. For a given volume, the Siemens' tube possesses a markedly large surface. With just bromine vapour no time-reaction of an ordinary kind is plausible. The above system energized at a constant potential showed during but a moderate period a marked diminution in its electrical conductivity, which finally reached a stationary value. If a discharge was now discontinued for a short interval and restarted at the original potential, the conductivity was much lower than the first initial value; this was restored to a greater extent the longer the period of discontinuation; finally, after standing over for about 24 hours, the original conductivity was attained. There is evidence to suggest that under the discharge the bromine vapour is dissociated into atoms and that this atomic and also molecular bromine activated in the discharge might be adsorbed by the container walls of the ozonizer, and that the desorption of bromine predominates on switching off the secondary potential. It may, however, be mentioned that suggested by the fact that bromine is strongly coloured, no evidence was obtained of any desorption induced by irradiation in the visible; this did not alter the time of recovery from the 'aged' condition of low conductivity. It was observed, however, that this irradiation of bromine during the discharge almost instantaneously reduced the conductivity, an effect to be disentangled from '*ageing*' (*vide infra*). Contrary to anticipation from analogy with like effects, the conductivity did not show any sensible periodicity when examined over a range of experimental conditions.

It is of interest to report here a remarkable type of periodicity effect observed in the behaviour of nitrogen peroxide [85] and especially in the interaction of a mixture of nitrous oxide and hydrogen [86] in the silent discharge. When produced thermally, the interaction yields nitrogen and water as by far the main products. The course of the reaction, therefore, was expected to be either a progressive diminution of pressure or its constancy, depending upon whether the temperature of the system was low enough to condense the water formed or high to keep it in a state of vapour. Actually, it was found that under the discharge (*cf.* Fig. 4) the decomposition mixture showed an initial marked rise of pressure up to a maximum; it then fell to a minimum, once again to rise, and so on, through a series of recurrences whose amplitude diminished gradually;

ultimately, the pressure became constant. It must be emphasized that all the operative conditions, such as the applied

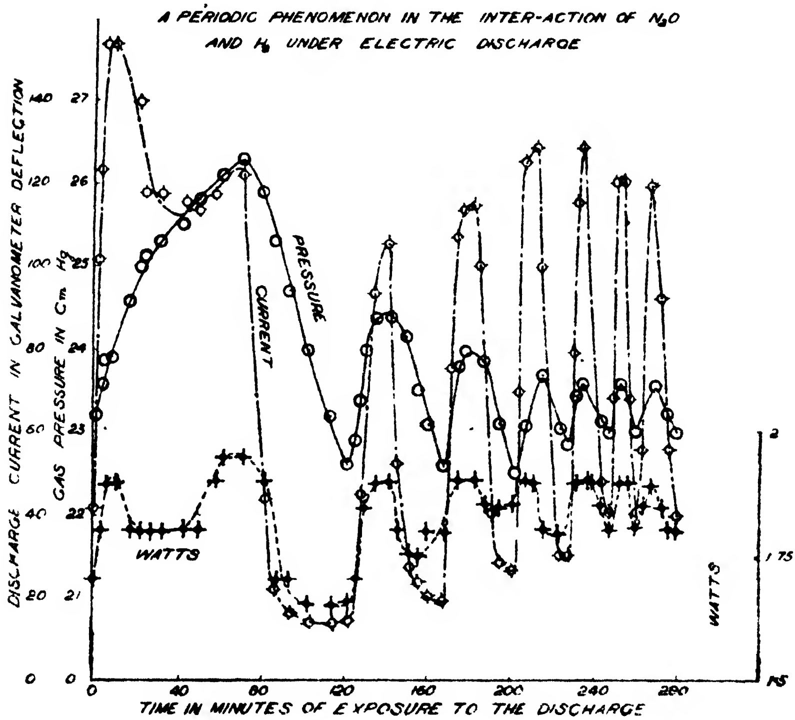

FIG. 4.

potential, frequency of the A.C. supply, temperature of the water-bath used to cool the ozonizer, were kept fixed during any given reaction. Whilst in part similar, discontinuous effects have been observed by Richardson [87] in the emission of positive ions from a hot platinum surface, and by Buff and Hoffmann [88] in the spark decomposition of carbon dioxide; the outstanding feature of the periodic effect now reported is that the contemporary quantities, such as the current flowing through, and the energy dissipated in, the reaction space (*cf.* Fig. 4) and the spectral appearance of the glow due to the discharge showed a variation which was remarkably synchronous with that of the gas pressure. Compared with the thermochemical change [89, 90, 91, 92], the discharge reaction was found to be more complex; besides undecomposed nitrous oxide, there were observed nitric oxide, nitrogen peroxide, nitrogen trioxide, ozone, water, hydrogen and nitrogen. A consideration of the reaction-time curves in one typical case shows (Fig. 4) that this is not only a case in which the progress of the change, as indicated by the pressure variation, alternately speeds up and slows

down; *there is a periodic reversal in the sense or direction of the reaction.* It may be added that this periodic effect is not produced when an initial excess of hydrogen is present. The influence of the other physicochemical factors, such as the applied field and other electrical constants, the temperature, the initial pressure of the mixture, etc., has been investigated. The conditions for the optimum development of the periodicity effect are such that the corresponding progress of the change is rather slow; thus, for instance, in one case as many as 20 well-defined recurrences of pressure-reversals and of the other electrical quantities mentioned already were obtained necessitating an exposure of 1,200 minutes to the discharge. Even after this time, there was no slowing down of the change, indicative of a near completion of the reaction. The behaviour of walls of the system, which form the electrodes in the kind of the discharge tube used, would appear to be important. These, under the influence of the applied potential, develop a strained condition as suggested by earlier work on the behaviour of bromine [84]. If now the assumption is made that the duration of this strained condition and the time needed for recovery therefrom during the progress of the present reaction is periodic, it is easily shewn that the corresponding field-intensity in the neighbourhood of the wall surface and the magnitude of the characteristic dielectric strength especially of the surface material would also be periodic; this would produce a like change in the time-rate of the discharge reaction, in the value of the corresponding current flowing through, and the energy consumed, in the system, and in the breakdown potential of the mixture as actually observed. As judged from the changes in the spectrum of the discharge during the ascending and the descending portions of the periods, an alternate condensation and evaporation of one or more of the products of the interaction would appear to be one of the determining factors in the production of the phenomenon. It may be added that an irradiation of this reaction mixture (unlike bromine) did not produce any detectable change in its electrical conductivity.

§8. A New Light-Effect.

Arising out of studies of reactions produced under electrical discharge, in progress for some considerable time at Benares, was the question of the influence on these systems of additional factors, such as (i) the temperature, (ii) an external magnetic field, and (iii) irradiation. Data in respect of (i) and (ii) are still in the process of accumulation [93, 94]. Studies of (iii), more than suggested by previous observations on the 'ageing' of bromine under light [84] and certain preliminary results on the hydrogen chlorine combination under electrical discharge, have disclosed the existence of what would appear to be a *negative photo-effect* [94, 95, 96] produced chiefly in gases under electrical

discharge. The effect is most pronounced in chlorine and the results now to be reported refer principally to its behaviour in Siemens' tubes. *It is found that subjected to ionization by collision by alternating electric fields, the conductivity in this gas diminishes immediately on irradiation*; it increases without any sensible lag to the original value on switching off the light. This effect is much less in bromine and very small in iodine vapour. That it is a much wider occurrent phenomenon than an electric analogue of the well-known Budde effect, is shown by the fact that it has been observed in a much greater number of gases [95, 96] under a wider range of conditions; the Budde effect has been noticed hitherto only in the halogens. Results of preliminary work in this line at Benares have shown that this light-effect is determined by a large number of factors, such as the (*a*) gas pressure, its temperature, and nature of the wall surface; (*b*) magnitude of the potential (or rather the corresponding field) applied to, the energy dissipated in, and the current flowing through, the discharge tube; the frequency of the A.C. supply and its wave form; (*c*) intensity and the frequency of the light used and probably the net amount of light-absorption [96].

Within the limitations of the available accessories, for a given range of the quantities grouped in (*b*) and (*c*), it is found, subject to limits, that a diminution of pressure and increase of temperature increases the photo-suppression. The nature of the container surface has also been found to exert a distinct influence on the magnitude of the corresponding light-effect. Thus, for instance, Deshmukh and Dhar have observed that this phenomenon in sulphur dioxide gas was practically completely abolished on the introduction of mere traces of sulphur trioxide which, being solid at ordinary temperatures, would form a film or patches on the inner walls of the discharge tube [96]. This influence of the nature of the wall surface was particularly noticeable in the case of ordinary permanent gases like air, hydrogen, nitrogen, oxygen, etc.[96]. Comparatively, the light-effect in these gases is very small and may be detected only with a specially sensitive arrangement and intense irradiation. A further remarkable instance illustrating this wall effect was observed in a Siemens' type tube which was filled with chlorine at a pressure appropriate to the maximum photo-suppression. This last persisted unaltered for a period of over three years when the gas was replaced with the usual precautions by hydrogen and subjected to discharge. The behaviour of this sample of hydrogen was markedly unsteady and in general abnormal. Furthermore, when this hydrogen was töplered out and chlorine introduced at the previous pressure, it was found that the system had become comparatively insensitive towards light. This may be ascribed to some change in the properties of the wall surface due to contact with gases activated under the discharge. Further abnormal results under special conditions are mentioned later.

Deo (unpublished results) working at Benares has measured this effect in the majority of cases by at least two independent methods; he has found that for a given condition in respect of (*a*) and (*c*), an increase of the discharge current in the dark obtained by regulating the electrical quantities under (*b*) increases Δi, the photo-suppression; the corresponding $\frac{\Delta i}{i}$, however, decreases.

In general, the light-effect increases by an increase under (*c*). It is interesting to add that changes in the light-effect due to intensity fluctuations are comparatively more pronounced under smaller than under larger intensities of irradiations. A general consideration of these results appears to indicate that as a simple-to-construct, and a sensitive source of a general *negative* light-response, the present phenomenon is almost unique in the known range of light-effects. The data obtained by Deo show that the influence of the light-intensity is more than linear. Under certain conditions, therefore, an arrangement utilizing the present phenomenon might well be more sensitive to fluctuations of the light-intensity than the photo-electric cell. It is well known that the amount of photo-electric action is proportional to the corresponding intensity of light. The present phenomenon would appear, therefore, to differ in an important respect from a possible negative photo-electric effect. Changes due to polarization of light, unaccompanied by change in intensity and wave-length, are within the margin of probable experimental error.[95]

Deo has found that the light emission from chlorine subjected to the silent discharge *observed under conditions of maximum photo-suppression* is exceedingly feeble in intensity. An exposure of at least 200 hours is necessary to get a reasonably measureable plate with the available instrument. For purposes of comparison, spectra of chlorine with and without irradiation, and of the light transmitted by the filter used, under identical conditions of duration as far as practicable in respect of other factors are necessary. One such result requires, therefore, a total exposure of 600 hours, *i.e.* more than 30 days, since under the best of working conditions even during the cold months at Benares, the available alternator cannot be run, with a 2-hour interval, for more than 18 hours a day. An unexpected break in the mains line or working of the apparatus or even an accidental non-constancy in any of the numerous determining factors, mitigating the comparability of results during the three periods mentioned, necessitates, as has happened time and again, the discontinuation of an observation which had taken already a toll of several days of exposure and almost continuous attendance needed in order to regulate the voltage, the temperature and other controlling factors. A careful scrutiny of the inevitably

few observations has revealed a number of significant results, chiefly in regard to the distribution of intensity within and without the spectral range transmitted by the light filter used. On general considerations, it is shown that a decrease of conductivity under irradiation as observed might come about by a like change in either or both the number of ions per unit volume or their average velocity in the system. If now the supposition is made that irradiation produces a reduction of the ionic velocity or that it favours a recombination of the ions, a decrease in the conductivity and an associated spectral change, especially in the intensity distribution, is to be anticipated. It is extremely likely that such a recombination requires a three-body collision and that it occurs appreciably on the container walls [98]. This is perhaps the cause for the marked influence exercised by the wall material in the production of this phenomenon. It may also be necessary to examine the possibility of the recombination of both the excited and normal chlorine atoms to produce chlorine molecules; or else the metastable molecules might revert to a more normal energy condition under irradiation. The rôle of a number of such factors plausible on general theoretical grounds has to be investigated before the precise mechanism of the effect is understood. Towards this end (observed under conditions of maximum light-effect), results of spectroscopic studies of gases subjected simultaneously to electric fields and irradiation with an instrument of a large light-gathering power will be of the greatest assistance.

Detailed work of Deo on the use of different spectral regions in the visible in producing the photo-variation in chlorine has indicated that the effect is negligibly small in the infra-red and maximum in the violet (4750–4000Å). It is also seen that the frequency is the more significant factor than the intensity. It is interesting to observe that the above region of maximum light-effect includes much of a characteristic absorption band of chlorine, *viz.* 2300–5000Å, and that chlorine does not possess a strong absorption band beyond 5760Å on the long wave side [47]. That the present phenomenon occurs appreciably on irradiation from a sodium vapour lamp and due to other frequency ranges fairly outside the absorption spectrum of chlorine [97, 103, 104], and especially the observation of Raghavan and Dube that the effect occurs in hydrogen under irradiation in the visible, where absorption (at any rate of neutral hydrogen) is but small, suggests, as a tentative basis for further enquiry, *that the phenomenon may be more a frequency or a quantum effect than a consequence of the characteristic optical absorption.* Results of work in a number of other systems already in progress at Benares are in agreement with this deduction.

On account of perhaps the large surface area which produces a greater amount of light-absorption at a given intensity, the

effect is comparatively marked in Siemens' tubes; it has, however, been obtained to more than a detectable extent in wire-in-cylinder type tubes or semi-ozonizers.

An outstanding and well-recognized conclusion arising from the spectroscopic, chemical kinetic and other evidences is the occurrence of a fairly far-reaching dissociation under any type of electric discharge [98]. Mutual interaction amongst the atoms and the radicals is, therefore, to be anticipated. Observation of changes in the light-effect with a progressive variation of the physicochemical condition of the system would appear to be well adapted as a general method for investigating the formation of complex molecules under electrical discharge. A beginning has been made in this line for a study of the inter-halogen compounds by observations of the photo-suppression; the results obtained already show the utilizability of this method [96].

Another field of research which promises to yield much useful information is the influence of the nature of the wall material on the light-effect. Suggestive results have been obtained already in this line by Murthy and Sahasrabuddhe with potassium iodide, iodine and sodium chloride. A coat obtained by slow evaporation of an aqueous solution of the above substances on the inner walls of the discharge tube has a pronounced influence: under certain conditions of temperature and the applied potential, the behaviour of the familiar type of the metal oxide rectifiers becomes markedly abnormal as compared with that of a vacuo-junction. It must be emphasized that with all the vapours and gases in electrical discharge under conditions investigated so far, the change of conductivity on irradiation, as indicated by the vacuo-junction rectification, has been either nil or negative; the oxide type rectifiers, of which different specimens were examined, showed, however, in some cases the opposite effect [96]. Furthermore, this apparent anomaly occurred within a restricted range of the gas pressures and especially the operative electrical conditions and has been noted in certain hydrogen-bromine, hydrogen-oxygen mixtures, hydrogen, oxygen, chlorine, water vapour and nitrogen peroxide under certain conditions. It would appear that when produced, this positive change is large at comparatively small potentials; it then decreases in magnitude and finally changes sign, *i.e.* shows the familiar photo-suppression, at potentials higher than the threshold potential. It is impossible to over-emphasize the importance, both from a theoretical standpoint and otherwise, of the possibility of obtaining positive photo-effects under controlled conditions, as suggested by the isolated observations mentioned above. It would appear that the chief need in this connection is of an exhaustive study of the behaviour of the oxide and similar rectifiers under a wide range of physicochemical and electrical conditions of the discharge circuit.

Reference may also be made to series of rather suggestive observations of Damri Singh on the increase in the electrolytic conductivity of a number of solutions studied under a wide range of conditions as to the temperature and concentration, due to a strong *volume irradiation in the ultra-violet* (the electrodes being screened in order to discriminate the phenomenon from the well-known Becquerel effect).[99]

In conclusion, I recall my grateful association with a band of young and ardent workers—not whole-time researchers—but students with the usual obligations of class work. They primarily have developed the subject by work during holidays, nights and the discontinuities of limited periods during the session. This and other deficiencies limited the speed but not their devotion to the work. The results mentioned in the last section have not only revealed the existence of a much suggestive phenomenon, but opened a new field of study and research. The light-effect now reported, or rather the chief details thereof, refer to chlorine under electric discharges. The ground covered is almost nothing compared with what remains to be investigated with this gas alone. Studies with other systems are likely to be of considerable interest; they are certainly necessary for a general elucidation of this new type of interaction between radiation and matter under conditions of electrical activation.

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SECTION OF GEOLOGY AND GEOGRAPHY

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Presidential Address

(*Delivered on Jan. 3, 1943*)

SUGGESTIONS FOR THE FUTURE DEVELOPMENT OF INDIA'S MINERAL RESOURCES

Introduction

When the General Committee of the Indian Science Congress Association elected me President of the Geology and Geography Section for the present session, the choice of a subject, whether it should be strictly scientific or more directly concerned with the mineral industry, required some thought. During the war period practical considerations demand all our attention. From my youth my life both abroad and in India has been constantly associated with mining in all its phases, and I have been fortunate in being able to pursue my 21 years of scientific work here continuously in connection with the mineral industry. Naturally during such a long association views are formed on improvements and developments which one would like to see instituted in the industry. Such views have nothing to do with politics: they arise naturally from an interest in one's job, and in a love of those regions of the country where we, as geologists, have spent so many strenuous years mapping in the jungle and contributing information concerning the mineral resources of this great country.

In India, the geologist, and particularly the Geological Survey of India, has a somewhat wider sphere of work than in other countries. This country does not possess that class of rugged prospectors who have been responsible for finding so much mineral wealth in such countries as Australia, Canada and the United States. Theirs was a hard existence and, apart from the lure of the El Dorado over the horizon, the only attraction was the independence and camaraderie of the prospecting camps—I still look back with pleasant memories to the days which I spent with prospectors on the tin and osmiridium fields of the west coast of Tasmania twenty-three years ago. In the absence of such men as these the foundations of the mineral

industry in this country have largely depended on the energies of the geologist.

Such opinions as are expressed in this address are offered not as criticism but objectively as the suggestions of one who, standing aside from the hurry and scurry of industry and trying to view the mineral industry as a whole, desires to leave some advice on the development of India's mineral industry as gained from his experience.

Discussion on the mineral industry may be divided into two closely related subjects: the future actual development of the mineral resources and the future administrative organisation of the mineral industry. The limits of our presidential addresses compel me to confine my attention to the first of these, but I hope shortly to discuss elsewhere the latter subject.

India's Mineral Position

It is commonly and mistakenly said that India is poor in mineral resources. Although India is not so rich in economic minerals as the U.S.A., it is by no means deficient. This country is indeed the world's dominant source of at least two minerals, mica and ilmenite; it shares with Russia in being the world's main producer of manganese, and possesses perhaps the world's largest reserves of high grade iron ore. In addition, there are adequate resources available of many other minerals. No country is completely self-supporting in mineral raw materials, for example, even in the United States there is a notable deficiency of tin and nickel. India's shortcomings comprise particularly tin, nickel and molybdenum. Some picture of India's position with respect to the principal nations in the world may be obtained from Table 1 (see pages 82 and 83).

It has been stated that such mineral resources as are available in India have not been developed as fully as they should have been. Confining attention to pre-war development and basing comparisons on progress in other countries, this statement is unjustified. In mineral production India could stand comparison with any other country of a similar degree of industrialisation, and the treatment and utilisation of many minerals within the country have not been unduly behind, if economic factors in production and the market's capacity for absorption are taken into consideration. I do not propose to discuss the rate of development during the war.

On the whole, India's mineral industry has been far from negligible and has been a valuable asset to the country. On it has been based industrialisation in general; for example, the very power on which cotton and jute industries depend is from coal; even hydroelectric power depends on the cement-concrete in the dams and the metals by which the power is transmitted.

DISTRIBUTION OF MINERALS IN INDIA

Between individual provinces in India there is an unequal distribution of minerals. Bihar possesses an outstanding wealth of minerals and produces in normal times about 40 per cent of India's total mineral output; indeed there are few regions in the world, of similar area to that of Southern Bihar or Chota Nagpur, with such a remarkably rich variety of valuable mineral resources, including deposits of coal, iron, copper, chromite, mica, aluminium, gold, limestone, phosphates, manganese, kyanite, talc, etc. I have recently given a full account of the mineral resources of this province in *Memoirs* of the Geological Survey of India, Vol. 78, which will become available to the public after the war. Next in importance come Mysore, Madras and Travancore in South India, where quite a considerable mineral industry is concentrated. Central Provinces and Assam add a useful quota to the total mineral output. The Punjab, Orissa, Baluchistan, Rajputana and Sind are unlikely to be comparable with these richer provinces whilst, with occasional exceptions, Bombay, Central India and United Provinces are unlikely ever to be important producers of mineral raw materials. Hence we see that west of a line drawn from Mangalore to Cawnpore and to the Himalaya, mineral deposits are not only sparsely distributed but are also unimportant, with the exception of mica, lead and perhaps copper in Rajputana, salt, coal and petroleum in the Punjab, and chromite and sulphur in Baluchistan.

Reviewing the distribution of minerals the lesson is driven home that all parts of India are interdependent and that a coordinated mineral policy applied to this country as a unit is desirable. The provincial distribution of minerals should receive profound study by politicians whenever partitioning is under consideration.

FUTURE EXPANSION OF THE MINERAL INDUSTRY

Expansion of the mineral industry may include the development of new mineral deposits and the creation of new industries from minerals already mined.

The finding of extensive new deposits in various parts of India can be scarcely expected in the future, but useful deposits of minerals will undoubtedly be found from time to time. Occurrences which we have known for many years will be brought into the industrial picture in the future; for example, our resources of bauxite will certainly be the foundation of a valuable aluminium industry. Even during the present war, the Geological Survey has stimulated the development of what we hope will prove to be valuable copper and lead-zinc-silver deposits.

TABLE

Relative Pre-War Mineral Production of

	India.	British Empire.	U.S.A.	U.S.S.R.	France.	Germany.	Italy.	Japan.	Other important sources.
Antimony ..		0[1]	0[1]	0[1]	0	0[1]	—	0[1]	China.
Arsenic ..	[illegible]	—	—[3]	=	◇	◇	◇	◇	Sweden.
Asbestos ..	—	C	—	◇	—	0	—	—	
Barium ..	=[2]	-	-[3]	=	--	+	◇	0	
Bauxite (aluminium ore) ..	=[2]	—	=	=	[illegible]	—[1]	—	0	
Beryllium ..	◇	—	=	0	0	0	0	0	South America.
Bismuth ..	0	-	—	—	0	◇	0	=	Peru, Bolivia.
Borates ..	0	0	C	—	0	0	◇	0	
Bromine ..	0	—	+	—	◇	◇		—	
Cadmium ..	0	=	-	0	—	=	=	0	
Chromite ..	[illegible]	+	—	◇	◇	0	0	—	Turkey.
China clays ..	—	◇	—[3]	—	—	-[3]		-	Czecho-slovakia.
Coal ..	=	◇	-	=	—	◇	0	=	
Cobalt ..	0	+	0	0	◇	0	0	0	Belgian Congo.
Columbite-tantalite ..	◇[4]	[illegible]	—	—	0	0	0	0	
Copper ..	—	◇	+	—	0	—	0	—	Chile.
Diamonds ..	—	--	0	0	0	0	0	0	Belgian Congo.
Diatomaceous earth ..	0	—	C	—	◇	-	—	—	Denmark.
Feldspar ..	=[2]	◇	[illegible]	--	0	—	—	-	Sweden, Norway.
Fluorite ..	0[2]	◇	—[3]	=	=	+	-	=	
Fullers earth and bentonite ..	-[2]	◇	[illegible]	=	0	0	0	0	
Gold ..	◇	C	◇	◇	-	0	0	◇	
Graphite ..	=[2]	=	—	=	◇	—[3]	=	+	Austria.
Gypsum ..	=[2]	[illegible]	—[3]	=	+	=	=	=	
Iodine ..	0	0	—	=	0	0	◇	0	Chile.
Iron ore ..	=[2]	=	+	◇	◇	--	0	—	

C : World control. + : Large excess. ◇ : Excess. = : Sufficiency.

[1] Some resources when necessary. [2] Resources can be further developed.

6B

I.

India and the Principal Nations.

	India.	British Empire.	U.S.A.	U.S.S.R.	France.	Germany.	Italy.	Japan.	Other important sources.
Kyanite-sillimanite ..	·		·	▬	0	0	0	0	
Lead	0[1]		⋮	▬	0	▬	▬	0[1]	
Lithium ..	0[1]	◇	◇	0		–	0	0	Argentine.
Magnesite	◇			◇	0	–	0	0[1]	Austria.
Manganese ..	+	·	·		0	0	0	– –	
Mercury .	0	▬			▬	0	+	–	Spain.
Mica ..	C	C	▬	–	▬	0	0	▬	Brazil, Madagascar.
Molybdenite .	0	0	C	0		0	0	—	
Monazite ..	C	C	0	0	0	0	0	0	Brazil.
Nickel .	0	C	0	▬	–	0[1]	0[1]	0[1]	
Nitrates ..	—	·	· [3]	– –			–	–	Chile.
Petroleum .		▬	C	◇	0	0	0	0	
Phosphates ..	▬	·	·	◇	+	0	0	0	
Platinum metals	0	C	▬	+	0	0	0	▬	
Potash	▬	0	[3]	◇	◇	C	0	– –	
Radium	0	C	▬	▬	0	0	0	0	Czechoslovakia. Congo.
Salt				–		◇	◇	▬	
Selenium .	0	·	⁝	0	0	0	0	0	
Silver ..	–	◇	+	=	▬	▬	▬	=	Mexico.
Strontium ..	0[1]	C	0	0	0	◇	0	0	
Sulphur .	0[1]	—	+	–	–	—	◇	=	
Talc ..	[2]	·	◇	—	◇	▬	◇	◇	Norway. Austria.
Tellurium ..	0	◇	◇	0	0	0	0	0	
Tin ..	0	+	0	0	0	0	0	0[1]	Bolivia. N.E.I.
Titanium ..	C	C	0	0	0	0	0	0	Norway.
Tungsten ..	–	+	– –	0	—	0	0	—	China.
Vanadium ..	0[1]	◇	—	0	0	0	0	0	Peru.
Zinc ..	0[1]	+	+	=	0	—	=	▬	Poland.

– : Deficiency. ▬ : Large deficiency. 0 : Negligible or entirely absent.

[3] Deficiency results from large consumption. [4] Occasional finds.

The greatest expansion is likely to be in the further treatment and utilisation of our mineral resources within the country. At least four minerals now mined in India—mica, manganese ore, ilmenite and monazite—are of great importance to the world's industries, but to-date almost their entire production has been exported in the unmanufactured state. These minerals must continue to be exported, but it is eminently desirable that much of the manufacturing processes through which they eventually pass should be completed in India before export. Within this country there is nothing to prevent the gradual expansion of the micanite trade from mica splittings, or the manufacture of titanium white from ilmenite, or the extraction of thorium oxide and cerium from monazite, or even the smelting of much of our manganese ore to ferromanganese. The technical difficulties of manufacture could be readily overcome in this country, the main problem would be in ensuring that other countries accept the Indian manufactured material in place of the raw mineral.

It may be useful to discuss the direction of expansion which may be possible for each mineral in the future.

Antimony.—Small deposits of antimony are worked sporadically in Chitral and Lahaul (Spiti) but they are very inaccessible and, except in times of stress such as in war, mining and transport costs are likely to be prohibitive.

Asbestos.—India's resources of asbestos are small and confined to relatively minor deposits in Madras, Mysore and Seraikela; specimens and an occasional unimportant production have also come from various other parts of India. The Madras deposits could undoubtedly be further developed. The output in India is never likely to be large and the importation of asbestos will apparently be always necessary. The greater part of the production is likely to be absorbed in the manufacture of asbestos cement. Unless large new deposits are found, very considerably increasing the production of high quality asbestos, the manufacture of asbestos textiles, yarns, cordage and cloth would scarcely be worth while in India.

Barium.—India's output of barite from Madras, Alwar, United Provinces and Bihar could be expanded to the capacity of the Indian market for absorption. The mineral is mostly required in the paint industry, but increasing amounts may be used in glass, enamels and glazes, and as a filler in motor tyres, paper and cloth. The manufacture of barium chemicals could also be undertaken even for export to adjacent countries.

Bauxite.—The total reserves of bauxite in India are very large and expansion of output is certain in the near future. Indeed, India is likely to become one of the world's most important sources of this mineral. Attention has already been given to the manufacture of alumina and aluminium, and expansion of output of these should not be difficult in the future.

With the production of alumina the manufacture of abrasives and of aluminium chemicals should receive serious attention; as cheap power will become available, Indian abrasives of the alundum type should be capable of competing with abrasives of other countries. The manufacture of alumina cement should receive more serious attention; its possible competition with Portland cement may have prevented development of this material to date, but each has its individual applications which should be clearly appreciated. The increased use of bauxite as a refractory material will be governed by domestic requirements of alumina firebricks, so that expansion of output for this purpose is unlikely to be considerable.

The mineral cryolite (sodium aluminium fluoride), most of which is obtained in Greenland, is required for the manufacture of aluminium. It can be made from alumina and fluorite; the fluorite deposits of Khairagarh and Nandgaon States might be used for this purpose.

Bentonite.—This variety of clay is used more particularly for filtering and decolouring oils and for treating the drilling fluids used in drilling for petroleum by the rotary method. It is also used in ceramics, foundry sands, soap-making and as a seal in engineering structures. Deposits in Kashmir and Jodhpur will receive widening attention in the future as the Indian demand increases, but there is unlikely to be any overseas trade in bentonite.

Beryl.—The metal beryllium is extracted from the mineral beryl, a silicate of beryllium and aluminium. The metal is used in special alloys, the mineral itself is used in ceramic glazes. India has been one of the chief sources of beryl in the past and still mines a useful output of a few hundred tons a year. As the production and the demand is likely to remain rather intermittent, the establishment of an industry in India for extraction of the metal cannot be recommended, unless it could be taken up by a company such as Tata Iron & Steel Co., or the Steel Corporation as an adjunct to their present activities. It is, however, doubtful whether the expenses involved would be compensated by the results. The position would be otherwise were the continuation of supplies of beryl within the country assured.

Chromite.—In India chromite, an iron chromium oxide of excellent quality, is obtained in Baluchistan, Singhbhum and Mysore, and the greater part of the production has been exported. Until recently almost the sole use of chromite in India has been for the manufacture of refractory bricks, but there is little likelihood of any important domestic development of this industry. Future expansion in the manufacture of chromium chemicals for use in dyeing, calico printing and tanning may certainly be expected, and this country may not only become self-sufficient in such chemicals but should be in a position to export them.

Similarly, the smelting of ferrochrome for use in special steels once established as a war measure should have little difficulty in surviving during peace, even for export purposes in competition with other countries.

Clays.—There are no large deposits of china clay in India but there are many small deposits scattered over the Peninsula. Few of these deposits approach in quality the standard of European clays. Consequently there can be little expectation of any great expansion in the mining of white clays for either ceramic purposes or for filler in paper-making. There is, however, scope for considerable improvement in methods of refining, and research in this direction is desirable.

Deposits of fireclays, and of clays suitable for the manufacture of stoneware tiles and other ceramic articles, are abundant, particularly on the coalfields. The expansion of this side of the clay industry may be expected to keep pace with market requirements. Research on improvements in the use of clays must be continued and will undoubtedly yield useful results.

Coal.—The coal industry has been of the utmost importance to India, but mistakes in mining and utilisation have been made in the past, as they have been made in other countries. Our efforts for the future should be directed at eliminating those mistakes and at improving methods of mining, marketing and utilisation, thus leading towards the conservation of the limited reserves available, particularly of coking coals. Every effort should be made to produce the innumerable by-products vital for the development of other industries. There is the talent available in the country to develop the coal industry on more rational lines, and a few leading firms have made progress in this direction. One's thoughts turn to nationalisation in the coal industry perhaps more so than in any other mineral industry.

It is not proposed to discuss here the details of future lines of development in the coal industry; much has been written on this subject in recent years and there is no dearth of suggestions. Briefly they may be grouped under the following heads: (*a*) improvements in methods of mining leading to conservation of reserves, and reduction of losses by fire and collapse, (*b*) improvements in methods of marketing, leading to some coordination of output amongst the collieries according to industrial requirements, (*c*) the more rational use of coking and non-coking coals leading to the maximum efficiency in methods of consuming the various grades of fuel produced on a coordinated plan, (*d*) the increased extraction of by-products and the establishment of other industries based on these products. Sound research is essential, but it will be difficult to obtain the complete cooperation of colliery owners, coke-producers and general consumers without some measure of direct Government intervention.

Cobalt.—Should the copper deposits of the Khetri area in Jaipur be developed in the near future, it is not at all unlikely that the associated cobalt may also be extracted. Deposits of cobalt are known in a rather inaccessible part of Nepal, but it is unlikely that they can be economically worked for many years to come, certainly not in the near future.

Columbite-tantalite.—These niobates and tantalates of iron and manganese are the source of niobium and tantalum, used in special alloys and as tantalum carbide in cutting tools. Small parcels of the mineral are intermittently found in various parts of India but the supply is not sufficiently consistent to warrant the complex treatment of these ores in this country.

Copper.—The Indian Copper Corporation in Singhbhum is working at its maximum capacity and further increased production of ore in that area would require the erection of new plant along the whole line of operations from the mine through the mill to the smelter. So far as the corporation's present mines are concerned they have apparently reached their optimum rate of production and it would be unwise to increase that rate. There is, however, scope for smaller companies to prospect other parts of the Singhbhum copper belt, such as at the south-east end and around Rakha Mines But it would be advisable for such small companies to sell their concentrates to the Indian Copper Corporation for smelting rather than undertake the expense of erecting an additional smelter in this region.

Copper deposits occur in several other parts of India, but I would recommend development of the Khetri deposits in Jaipur, whilst deposits in Darjeeling district certainly appear to warrant further investigation.

There has been much ill-informed talk in India of the manufacture of electrolytic copper. The electrolytic process is generally adopted where the copper ore contains also such precious metals as gold and silver. The difference in price between electrolytic and furnace-refined copper is generally only about 30 shillings per ton. In this country there is a very large market for brass, for which purpose the furnace-refined copper of Singhbhum is entirely suitable, and the Indian Copper Corporation have been very well advised indeed to adopt the furnace method of refining.

Should the ores of Khetri or Darjeeling be found to contain precious metals then the adoption of electrolytic methods in these localities may be justified.

It would seem that copper mining in India is likely to remain an anxious undertaking. In Singhbhum assay values and lode dimensions are small and the margin of profits in normal times is a minimum, but provided that the price of copper remains above £35 a ton, with retention of the present import duty, and there are no political and labour difficulties, the industry should have many years of life ahead of it.

Diamonds.—India's very small production of diamonds is mainly from Central India. There is little possibility of any appreciable expansion in the industry, but every encouragement should be given to those producers who endeavour to work on modern lines.

Feldspars.—Orthoclase and plagioclase are available in many parts of India and have been more particularly produced in Rajputana and Mysore. As the glass and ceramic industries expand, supplies of these minerals will be adequate. A rock known as nepheline syenite, which has a similar use in the glass and ceramic industries, is abundantly available in Kishengarh.

Fluorite.—The only probable useful deposits of fluorite in India occur at the borders of Khairagarh and Nandgaon States, but even these deposits are low grade as compared with fluorite deposits at present worked in America and Europe. If the local deposits are to be used for steel manufacture, or for chemical, ceramic and other purposes, beneficiation of the raw material to improve its grade will be essential. The only method likely to be successful is flotation, which has been successfully used on fluorite in America. This treatment will of course increase the cost, but can provide a high grade product. It is essential, therefore, that the fluorite be used for purposes in which a high grade material is essential, such as for the manufacture of artificial cryolite (for the aluminium industry) or as the source of fluorite and hydrofluoric acid, or for the manufacture of carbon electrodes, calcium carbide and cyanamid. I would deprecate the use of our limited resources of this mineral on steel smelting, as for this purpose a somewhat lower grade than that of the beneficiated product could be imported.

Fullers earth.—There are very extensive resources of fullers earth in Bikanir, Jodhpur, Sind and Khairpur, with some also in Jubbulpore, Mysore, Jaipur and Jaisalmer. Production will never have difficulty in keeping pace with requirements in India; as with bentonite, no export trade may be expected.

Glass sands.—Research on the raw materials for glass manufacture has become increasingly energetic in recent years and will undoubtedly give useful results. Known deposits of really high grade sands—mainly friable sandstones—are not particularly abundant in India, but we may expect to find additional sources in the future. The glass industry is gradually expanding and will continue to expand as imports are far in excess of the domestic production. Increased output of the better quality glasses and manufacture of plate glass is desirable, and the production of optical glass would assist the firm establishment of an optical instruments industry.

Gold.—The gold mines of Kolar are gradually attaining even greater depths. The present depth of the mine workings could scarcely have been anticipated 25 years ago, and it would be unwise to speculate as to the limit of depth which may be

possible in the future. The engineering difficulties attendant on increased temperatures and rock pressures may continue to be overcome within limits and so long as the gold content of the deposits permits economic working.

The deposits so far found in other parts of India have been small, and the discovery of deposits comparable with those of Kolar does not seem hopeful.

Graphite.—Although carborundum and other materials have restricted the demand for graphite for refractory purposes, it still has quite a wide use as a facing to foundry moulds, in paints, pencils and lubricants, and in electrodes, dynamo brushes and dry batteries. Small deposits have been intermittently worked in scattered parts of India, in the Eastern Ghats, Betul, Travancore, Kolar and Ajmer-Merwara. Compared with the Ceylon deposits, the Indian deposits are low grade. Beneficiation by flotation is desirable on all Indian material but any important increase in production of this mineral cannot be anticipated over a prolonged period after the war.

Gypsum.—India has extensive deposits of gypsum in the Punjab Salt Range, and important resources occur also in Jodhpur, Bikanir, Sind, Jaisalmer, Garhwal, Kashmir and Trichinopoly. Production is certain to increase gradually for use not only in special cement and for conversion to plaster of paris, but also in paint and paper and as a fertiliser. The production of sulphur or sulphuric acid from gypsum, with the concomitant manufacture of cement, is likely to be one of the most important lines of development in India in the near future. Should such an industry be established, it will naturally be accompanied by the manufacture of heavy chemicals. The obvious site for such an industry is in the Punjab Salt Range where salt, gypsum, limestone and coal are found together.

Iron ore.—India's deposits of high grade iron ore are so vast that this country will still have great reserves when the resources of the majority of other countries are depleted. The deposits are most extensive in Singhbhum and the adjacent Eastern States, but others occur in Mysore, Bastar and the Central Provinces. At present the main smelters are at Jamshedpur and Asansol, and there is a small smelter in Mysore. The development in the near future of a smelting industry in the Central Provinces is conceivable, based on the iron ores and limestones of Drug and adjacent States; although the coals of Korea and Rewa are non-coking, research may solve this problem.

The expansion of the iron and steel industry can be safely left in the competent hands of the present steel companies. It is to be hoped, however, that the production of ferro-alloys, the raw materials for which are available in the country, will be increased up to the market capacity for absorption both here and abroad. Indian iron and steel is certainly capable of competing both in costs and in technical skill with any other

country, and the impetus provided by war requirements is likely to continue into the peace. Exports of pig iron and steel are not likely to be great in the near future, and expansion of the steel trade will depend largely upon India's increased ability to undertake the manufacture of all forms of machinery and iron and steel articles for general industrial expansion.

Beyond the next 40 years when the known metallurgical coals will be exhausted, the steel trade will depend either on discovering some means of obtaining a coke from the present non-coking coals or on smelting iron by some other method than by the present blast furnace. Even today vigorous research on new smelting methods is advisable. Alternatively, the future may witness a close interchange between India and Australia—the former's iron ore for the latter's coal. A practical economic alternative method of smelting without coke would revolutionise the iron-smelting industry, and distribute it far more widely over the country.

Kyanite, sillimanite.—Both of these minerals, whose properties are practically identical, are found in India. They are used not only as valuable refractories, particularly in glass-melting, but also in certain special porcelains. Perhaps the largest deposit of kyanite in the world occurs at Lapsa Buru in Kharsawan State, other deposits have been worked in Singhbhum. Deposits of sillimanite in Assam, Rewa, Central Provinces and Bastar State are comparatively inaccessible. To-date the whole of the Indian production has been exported, the high local selling price of the raw material has prevented its manufacture into refractory bricks in the country, notwithstanding that the actual cost of mining has been quite low. Whether it would be economically feasible to calcine the raw mineral in this country, and ship it abroad either as calcined kyanite or even as manufactured brick, deserves thorough investigation, but this would certainly depend initially on a reduction in the price of the raw material. It does appear to be absurd that this country, the source of one of the finest refractory and ceramic materials known, should not have developed the mineral industrially.

Lead.—No economically workable lead deposits have so far been mined in India. The lead-zinc deposits of Zawar in Mewar, Rajputana, are at present under investigation. Another deposit in Jaipur State may also repay development. Other small deposits which have been reported from time to time in various parts of India all appear to be much too small to be possibly worked on modern lines. It is hoped that the Zawar deposit will develop into an economic proposition, for a lead-zinc supply would be a most important contribution to India's industrial metals.

Limestone.—The reserves of limestone available in this country are so great that there need be no anxiety about supplies

for the cement industry, and the latter may be expected to develop in step with market requirements. The use of lime for chemical purposes is capable of great expansion should demands for such materials as bleaching powder, calcium carbide and cyanamid increase. For the latter purposes a very pure grade of limestone is desirable, and this is not abundant in India, but deposits are available in the United Provinces, Punjab, Baluchistan and Jodhpur. Research is advisable with the object of determining a simple and cheap method of beneficiation of lower quality limestone.

Lithium.—The only known Indian deposits of lithium—the mineral lepidolite—occur in Bastar State in a somewhat inaccessible location, but, when India's glass industry is developed to the stage when such special materials as lithia are required, the mineral will undoubtedly be mined. The possibilities of extracting lithium from lepidolite might also be examined, either as metal for use in special alloys or as lithium salts for various purposes.

Magnesite.—India has excellent deposits of magnesite, mainly in Madras and Mysore, but small deposits occur also in Idar State. So far the material has been used for the manufacture of refractory bricks or for special cements, but the extraction of magnesium metal will receive early attention. For the latter purpose the Indian magnesite is especially suitable because of its purity and low iron content, and there is no reason why a sound industry should not be founded in India, particularly if the production of aluminium, with which magnesium is usually alloyed, is also firmly established. Calcium carbide and other fluxes required could be manufactured in the country.

Manganese.—India's deposits of manganese are of high grade quality and although the principal deposits are in the Central Provinces others are widely scattered—in Bihar, Eastern States, Orissa, Madras States and Western Indian States. Research in the improvement of low grade ore by mechanical means may give valuable results. Although export of manganese will always be advisable, the conversion of much of the ore to ferromanganese before export should be attempted. There is also considerable scope for increased application of manganese in domestic industries. The manufacture of dry batteries containing local manganese ore has become quite an important, although small, industry and is capable of expansion. The development of a manganese chemical industry may also be expected, and the increased local production of special manganese steels and other alloys is desirable.

Mica.—The mica industry in India is well developed, and the mineral is amongst India's most important exports. The export of block mica must continue in the future, but there is no domestic reason why the greater part of the condenser films now exported should not be cut to shape in this country. In

India, the manufacture of various kinds of micanite is in its infancy, but will undoubtedly expand, and with increased skill it is not improbable that a large proportion of the mica splittings may be converted into micanite locally. It must never be forgotten, however, that should the cost of various forms of mica be unduly increased to other countries, the latter may be forced to look around more energetically for substitutes.

The increased use of ground mica from scrap may be expected in India. With extensive dumps of scrap mica available there is scope here for considerable research.

Mineral pigments.—The paint industry in India is gradually expanding and the country's resources in mineral pigments will be slowly developed as required. Methods of improvement in the quality of the raw materials may need attention in order to maintain the rigid standards now required by paint consumers. In this country we have the raw material for titanium dioxide, perhaps the most valuable of all paint and lacquer bases.

Monazite.—It is difficult to understand why the monazite exported from this country has not been treated locally for the extraction of thoria and cerium. Although the domestic market for these is small, just as ready a market overseas should be found for the manufactured material as for monazite.

Nitrates.—The production of natural nitrates in India has decreased during the last 25 years, but it is not unlikely that if the collection of the nitre efflorescence on the surface soils of northern India were organised the recovery could be improved.

Most of the world's supply of nitrates is derived by the fixation of nitrogen from the atmosphere. The possibilities of this industry in an agricultural country such as India must be attractive, still, with the general indifference to the use of fertilisers, it is perhaps not surprising that it has not yet been attempted in India. But, as the village agriculturist learns more about modern methods, the possibilities of establishing a nitrate industry will increase; indeed the establishment of such an industry, possibly with the aid of a Government subsidy, would be one of the finest contributions to India's agricultural advancement.

Petroleum.—India's main oilfields are in Assam and the Punjab. While their output is of considerable importance in the Indian market, it amounts to only a minute fraction of the world's total production of petroleum. Most of the places where there are obvious surface indications of the occurrence of petroleum have been examined, with results which are negative from the point of view of the development of commercially productive oilfields, though large sums have been spent on prospecting, and still larger on exploratory drilling. Some time before the present war began one of the major operating companies had undertaken an intensive search for potentially productive areas.

This search was being carried on by a large and specialised staff of geologists and geophysicists utilising the most modern methods and equipment. It is noteworthy that these methods included the wide application of photo-geology, which is the geological interpretation of stereoscopic aerial photographs, a recently developed technique which is rapidly becoming one of the most powerful weapons in the armoury of the petroleum geologist. The war has necessitated the suspension of all these activities, so that the oil companies can concentrate their efforts upon the intensive exploitation of the known fields; not until hostilities end are either personnel or equipment likely to become available for the resumption of exploration on any wide scale.

Phosphates.—The apatite deposits of Singhbhum have never received the attention that they deserve. Surely it should be possible to find a use for these phosphates, either for metallurgical, chemical or agricultural purposes. The deposits are very accessible, right on the railway, and could be cheaply worked. Hopes in this direction may perhaps be realised in post-war development.

Potash.—Apart from the potassium nitrate deposits of the Gangetic plains there are no important occurrences of potash in India. Deposits of feldspar are abundant enough in India, however, and research into the use of feldspar for its potash content should yield valuable results. There is practically no recoverable potash in Indian blast furnace flue dusts. Research on other flue dusts may possibly furnish useful results.

Salt.—The great deposits of rock salt in the Punjab, and the various salt works using lake and sub-soil brines and sea-water, are well able to produce up to the country's requirements. The manufacture of caustic soda, sodium salts and chlorine from common salt should steadily increase in the future with the expansion of India's chemical and other industries. Residual bitterns from salt works should receive more attention for the extraction of potash and magnesium chloride, and even perhaps for bromine and iodine.

Silver.—Silver is being used increasingly for purely industrial purposes in various alloys. However, India's production of this mineral is unlikely to increase, unless the lead-zinc deposits in Mewar should prove successful.

Strontium.—The deposits of celestite (strontium sulphate) of Trichinopoly district will be used in the future, presumably in the paint industry or in pyrotechnics. Strontium may also, perhaps, find a certain small use in Indian metallurgy. However, the mineral is unlikely to give rise to any extensive industry.

Sulphur.—Until recently India's requirements of sulphur were imported. The situation has been relieved by the development of natural sulphur deposits in Baluchistan, but it is

doubtful whether high freight charges will permit these to remain paying propositions after the war. There are one or two small deposits of pyrite, in Bihar and Simla hills, which could be used for the manufacture of sulphuric acid, and the roaster gases at the copper smelters in Singhbhum could be used for the same purposes—there would be no inherent difficulties to overcome, but it would be advisable to utilise the acid at the works, for manufacture of chemicals. There are possibilities also of utilising the sodium sulphate which occurs in reh soils of the United Provinces and Bihar, and in the bitterns of Sambhar and Didwana Lakes. However, the important future source of sulphur in India is likely to be the gypsum deposits, particularly those of the Salt Range. The firm establishment of sulphur production, either as sulphur or acid, on a considerable scale is likely to witness the rapid expansion of chemical industry in India.

Talc.—The excellent deposits of talc available in India are capable of supplying any demand for refractory material or for acid-resisting tanks and slabs, or for powder to be used as filler or as a polishing medium, or for cosmetics, etc. As the market demand for these increases so will production.

Titanium.—The entire output of ilmenite from the beach sands of Travancore has been exported. With power available at a reasonable cost there should be no insuperable difficulty in manufacturing titanium white in this country from the ilmenite. Until this is done, the only return India is likely to gain from this important raw material is the royalty payments made to the State. Besides the manufacture of titanium dioxide for export and for local use in paints and lacquers, the manufacture of ferro-titanium alloys and of special titanium compounds for various purposes should not be beyond India's technical capacity in the near future. The Travancore beach sands have been worked intensively in recent years and there is a limit to their reserves, but other ilmenite-bearing sands are available at places along the east coast.

Tungsten.—So long as the wolfram deposit at Degana in Jodhpur is workable it should be able to provide all that is necessary for the local requirements of ferro-tungsten alloys. India will be well able to produce her own tungsten steels, and the manufacture of tungsten carbide may be possible in the future.

Vanadium.—With the manufacture of ferro-alloys in India the vanadium-bearing titaniferous iron ores of Singhbhum and Mayurbhanj are certain to be developed. Actual consumption of vanadium is quite small, however, and as India's own metallurgical requirements would be normally of the order of 100 tons annually, attempts at finding an overseas market would be advisable. In competition with such producers as Peru, Northern Rhodesia and the United States, success in exporting

would be doubtful. However, once a method for successfully treating these vanadium ores has been obtained, other uses may be found for the oxide such as in paint driers, in pottery glazes and special glasses, and in insecticides, fungicides and fertilisers. A wide field of research is awaiting investigation on these ores.

Zinc.—Unless the Zawar lead-zinc mines are successful there is no prospect in India of a zinc industry.

Direction of Mineral Investigation

There are several lines along which enquiries may be pursued with a view to the ultimate expansion of the mineral industry. The stimulation of prospecting must be coordinated with methods of prospecting, the mineral deposits must be closely studied geologically to obtain the maximum from the resources available, methods of mining must be improved, and also methods of treatment, whilst the extended use of minerals in industry must receive constant attention. I shall comment briefly on each of these directions of investigation.

1. *Stimulation of prospecting.*—Mineral prospecting in the past has depended either upon casual finds or on the work of geologists, including not only officers of the Geological Survey of India, but also industrial geologists.

The work of officers of the Geological Survey of India is very broad in scope. Theirs is a long-established and whole-time service and, because of the limited number of the department's staff, officers must necessarily take an interest in all phases of geology. Their fundamental task is the detailed geological mapping of the country, and from this springs their ability to give expert advice on such matters as prospecting, development of mineral industries, water-supply and geology as related to engineering problems, and soil surveys. Normally the function of the Government geologist is not that of a prospector, such mineral deposits as officers have found have come to their attention in the past during the course of routine mapping. With the creation of a special prospecting department within the Survey the more intensive searching of individual areas should be possible, comparable to the work of industrial geologists who may prospect mineral leases in great detail, foot by foot.

The scope for the discovery of new minerals in India is rather limited. In normal times the industry is fully able to take care of its own prospecting requirements; but should Government undertake the intensive search for such minerals as asbestos, barite, chromite, copper, glass sands, gold, graphite, kyanite, lead, manganese, mineral pigments, sulphur, etc., a special prospecting department with staff would be essential.

This work would be done preferably by the Central Government rather than by Provincial Governments.

To encourage an interest in minerals simple information may be disseminated amongst villagers, and they should be encouraged to bring in samples, with the payment of bonuses for any useful finds.

2. *Geophysical prospecting.*—Geophysical methods of prospecting have not as yet received much attention in this country except, of course, in the oil industry. Although they have been of great use in oil prospecting, geophysical methods have been disappointing in the few cases where they have been applied to prospecting for mineral deposits here in India. At the present time they would appear to have only a limited application in the mineral industry, such as in tracing the continuation of manganese deposits beneath the alluvium in the Central Provinces. Geophysical methods of prospecting will undoubtedly slowly advance in technique in the future and may eventually have a much wider scope than at present.

3. *Geological study of mineral deposits.*—During the mining period a mineral deposit should be geologically mapped in detail, and continuous detailed geological information should be collected during its history. The information thus obtained is commonly of great assistance in the development of the deposit, and may indeed lead to an increase in reserves and to reduction of costs by a better understanding of the structure. The information gained from working mines may be of value in prospecting for other similar deposits in the vicinity, or may even bring to light other hidden deposits. Thus the maximum use is made of the reserves available.

It may be advisable in certain cases for Government to examine mineral areas thoroughly before allocating leases. For example, it would lead to more efficient development, working and marketing of coal, if, in a new coal area, Government first thoroughly prospected all the seams, obtaining full information as to thickness, analyses and structure. In the lease requirements some stipulation could then be made as to the method of mining and the sequence in which the seams must be mined.

4. *Methods of mining.*—Mining methods in India, except in the mines developed by the larger companies, are rather primitive. There is scope for considerable improvement in working both surface and underground mines. Increase in the employment of technically trained staff will bear effect in the course of years. Advice on certain phases of mining published in the form of circulars by a central body, such as a Minerals Research Bureau, would certainly be of value.

5. *Petrological and chemical study of ores.*—Certain ores are complex mineral aggregates and, although their chemical composition may be determined by analyses, careful microscopic examination both by transmitted and reflected light may provide

invaluable evidence leading to improved methods of treatment. In some ores certain metallic constituents were at one time thought to be in solid solution or even in chemical combination with other minerals, but examination of polished sections by reflected light under high power magnification has shown that the particular metallic constituents may be in distinct minerals. There is in India a considerable field for investigation along these lines and it may be undertaken more particularly within the scope of a Minerals Research Bureau.

6. *Minerals and Metals Research Bureau.*—Other industries in India, such as jute and agriculture, have received a considerable impetus and assistance by the establishment of research institutes and it is perhaps anomalous that the most fundamental of all, the mineral industry, should not have received comparable attention. There is a very great need of a Minerals and Metals Research Bureau to undertake investigations into all aspects of the mineral industry, but mainly with a view to improve methods of mining and to improve grade for marketing or further treatment or to reduce cost of treatment and also to extend the application of certain minerals into fields other than those in which they are already used. Such a Bureau would include a Fuel Research Station, which has been so long advocated. I have already outlined the minerals awaiting investigation by such a Bureau in India.

State Aid

Apart from the actual prospecting of mineral deposits, and the setting up of a Minerals and Metals Research Bureau, there are certain other ways in which the State can assist the mineral industry. The maximum assistance could be rendered, of course, only if the industry were completely nationalised and undertaken by Government along the whole line from production to marketing. This goal will eventually be realised some day, but until then it is obviously in the interest of the country that Government should obtain the maximum revenue from its mineral resources consistent with the efficient and profitable working of the mines, and that every encouragement should be provided to make the maximum use of the mineral resources available. The two factors are not inconsistent, rents, royalties and taxation can be kept within limits to leave a reasonable profit; indeed, as encouragement of industries results in expansion, revenue from rents, royalties and taxation may be expected to increase.

Industries should be encouraged to make the maximum domestic use of local raw materials rather than that they should be exported untreated. For example, I should like to see all the manganese deposits of Singhbhum and adjacent Orissa States reserved for the Indian iron and steel trade, as these areas are more accessible to the steel works; export of ores from the Central Provinces and elsewhere would continue. I would

also advocate that preference in lease allotment in the Singhbhum and Orissa areas be given to the steel companies and to local users of manganese ore (for batteries, etc.).

It is not always advisable to hasten the mining of certain minerals; as related industries are built up, some minerals may find a more important use within the country and thus have a higher value than if they were merely exported in the raw state.

The development of further industries will depend not only upon the market's capacity to absorb the products but on the availability of cheap power. Industries tend to segregate more particularly in Bihar and Bengal where fuel is cheap. There are two opposing views: the engineer before designing his power scheme wants to know the local power requirements, the industrialist on the other hand looks around for localities in which power is available. If provinces desire to attract industries, they must take a chance and provide power; if necessary, invest considerable capital in hydroelectric schemes.

From the point of view of both mineral conservation and the most thorough use of the country's resources, it is preferable to encourage those with plenty of capital to develop mineral deposits rather than those who have very little capital. Bauxite, clays, chromite, coal, copper, iron, limestone, manganese and mica, all require considerable investments to mine them efficiently and to ensure that only the minimum of reserves are lost. The small miner would still have scope amongst such deposits as small gold veins, ochres, road metal, railway ballast, sands and perhaps soapstone. Ultimately, of course, Government is the largest capitalist, and logically should be the dominant miner. It is commonly claimed by industrialists that Government is an inefficient producer, but it should be borne in mind that the chief interest of the industrialist is to make a profit whilst Government is concerned with making the maximum use of the country's resources. Hence Government's chief interest may become maximum ultimate recovery of the minerals irrespective of the profit, accepting in some cases a loss. A monetary loss to Government may mean, however, a very great gain to the community.

From time to time one meets with instances of small producers who are unable to market their minerals, or of small consumers who are unable to obtain materials which are available in the country; some cooperative form of marketing may be useful such as the Mineral or Metal Exchanges in some countries. Government may provide the liaison necessary, and indeed some of the functions of the Supply Department may be usefully retained after the end of the war.

Control of the marketing and use of coal is particularly desirable, possibly even compulsion in the use of certain inferior grades may become necessary. This would obviously require

widespread reorganisation of the whole industry, with enforced cooperation which is unlikely to be obtained without some form of Government control, but it must come sooner or later.

A well-organised industry requires for its efficient working a knowledge of the actual quantities of various raw materials produced within the country. Statistics of mineral production should be complete and should be issued at regular intervals and without delay.

The mineral industry, like other industries, is subject to income-tax, various cesses and other forms of taxation. Complaints arise from time to time that some of these taxes bear unduly heavily on the industry, or are unfair, or are badly administered. Such complaints are generally merely the natural grouses of anyone who pays out something without seeing a direct return, but occasionally the complaints are justified. Unlike all other industries mining is based on the extraction of a wasting asset, an asset which once taken from the ground can never be renewed, and taxation authorities do not perhaps always appreciate this but tend to deal with mining exactly as with other industries. It is very easy to kill a primary industry of this nature by such heavy taxation that overseas markets are lost. In all taxation measures which affect mining, expert technical advice should be sought invariably.

On the other hand, Government may assist industries by import tariffs. Whether such a tariff is wise in any particular case will depend upon whether the added cost to the community is economically compensated by the benefits accruing from the local establishment of that industry. Considerations of this nature require a close appreciation of the technical, industrial and economic factors involved. The imposition of export taxes on some raw materials may assist the establishment of industries in India, by tending to hold the better quality raw material for the use of local manufacturers.

Conclusion

This address has been largely based on the national aspect of India's minerals. There is, however, a wider aspect—the significance of a country's minerals to the world as a whole. During the past year there has been a marked and increasing tendency amongst the people of the free world to think internationally rather than nationally. The desirability of the ready availability of raw materials amongst nations is more clearly recognised. One may hope that each country will consent to frame an international policy for the coordinated and rational utilisation of mineral resources throughout the world. If this country is to take its proper position amongst the nations, it will be necessary to conform to whatever general scheme of international mineral policy that may emerge. We may have to

learn to think here, as elsewhere, neither provincially nor nationally, but to regard ourselves as the trustees for the world of those minerals within our territory which mankind in general needs.

At the moment such considerations may appear theoretical, but their intensely practical significance may be appreciated when we remember that the next 100–200 years will witness a vast diminution in the mineral resources available throughout the world. However, I feel that the time for detailed discussion of future international policy, and of how India will be affected, is not yet, but we must await the emergence of the post-war international political framework. I can only hope that when the time for discussion arrives the Indian mineral industry will have adequate technical representation.

Most of us are perhaps sceptical regarding the future. Should an international mineral policy emerge, many of us are certain to be critics of its detail; let us hope that such criticism will never be checked, for it will be constructive and thus form the basis of advancement.

SECTION OF BOTANY

President :—KALIPADA BISWAS, M.A., D.Sc. (EDIN.), F.R.S.E.

Presidential Address

(*Delivered on Jan. 4, 1943*)

SYSTEMATIC AND TAXONOMIC STUDIES ON THE FLORA OF INDIA AND BURMA

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INTRODUCTION.

It is a matter of great pleasure and pride to me to address you as President of the Botany Section this year. Although India owes a debt of gratitude to the Royal Botanic Garden, Calcutta, for the inception and development of botanical, agricultural, horticultural, arboricultural and silvicultural researches and investigation on medicinal and economic plants, only one of my predecessors, some of whom are of world-wide fame, have had the privilege to hold the present office which I have the honour to hold at this session of the Indian Science Congress Association. For this honour I am indeed grateful to you.

We are within the grip of a total war which has seriously affected our scientific activities and those of other nations whose countries have been theatres of destruction and bloodshed. I have been much handicapped in writing my address, as all the literature and specimens have had to be packed up and removed to Darjeeling as a measure of Air Raid Precaution.

It was in 1899, the year of my birth, that one of the most distinguished systematic and taxonomic botanists of India—the late Sir George King, Kt., D.Sc., M.D., F.R.S., K.C.I.E.—

reviewed, in his presidential address before the British Association at its Dover session, the position of systematic studies in India. One hundred and fifty-five years have elapsed since the beginning of the systematic and taxonomic studies in India and it is not inappropriate to discuss the present position in India and the future scope of studies on the various branches of the plant kingdom.

Sir George King in his concluding remarks to his address expressed his regret at the indifference to the investigation of systematic botany in India. The position during the course of more than a century and a half has not, however, improved very much. At the time of the celebration of the 150th anniversary of the Royal Botanic Garden, Calcutta, during the Silver Jubilee Session of the Indian Science Congress Association in 1938, I realized from the messages and opinions received from the greatest authorities of the world that India should continue making further contributions worthy of her past achievements in the systematic and taxonomic studies in the light of modern researches. There remain yet vast fields to be explored in the Phanerogams not to speak of the Cryptogams which are very little known to us even at the present day.

Nevertheless, it is gratifying indeed that during the course of the past 40–50 years large numbers of papers have been published in the various branches of botany and that Indians have made serious attempts to take their legitimate share in the contributions, particularly in the last quarter of a century. Investigations on plant physiology by one of the greatest scientists of India, the late Sir Jagadish Chandra Bose of the famous Bose Institute, earned the admiration of the scientific world. In the realm of Palaeobotany we have in Professor Birbal Sahni, F.R.S., one of the greatest authorities. The late Professor Kashyap's work on Indian Liverworts and the accounts of his botanical expeditions in the Manassarowar earned for him an undying fame. In mycological investigation the names of Professor K. C. Mehta, Sc.D. (Cantab.), Prof. S. R. Bose, Dr. H. P. Chaudhuri and Dr. K. D. Bagchee are well known. We are all proud of these and other promising true devotees of botanical science in our country. A scrutiny of the publications of the botanical researches in India from the latter part of the sixteenth century up to the present day reveals that up to now nearly 4,500 papers have been published on the various branches of Indian botany. Thus an average of 12 papers per year have been published in India. This for a country like India is a very small figure. Moreover, up to the first decade of the twentieth century, it is only the foreign botanists who made contributions towards the advancement of our knowledge in systematic botany. From 1910 onwards, there has been growing activity among the Indians and, particularly, the last 30 years may be called the period of renaissance for botany in

India. During this period contributions made by Indian botanists in Cytology, Physiology, Anatomy, Embryology, Genetics, Plant Breeding and Plant Diseases and other allied branches outnumber those of the foreigners. But in systematic and taxonomic work, unfortunately, seventy per cent of the contributions have been made by foreign botanists. Systematic study has not received the attention of Indians that it deserves.

Brief History of Systematic and Taxonomic Researches in India and Burma.

The history of systematic and taxonomic investigation in India on the lines followed in the western countries can be divided into three main periods. The first period begins from 1768 extending to 1848, the second period from 1848 to 1900 and the modern period from 1900 to the present day. Systematic researches of the first two periods have been reviewed in a masterly way by Sir George King. It may not, however, be out of place here to give a brief sketch of these two periods and then connect the earlier activities with those of the modern period.

The first period starts with the pioneer worker, John Gerard Koenig, who was the first to introduce in India the binominal nomenclature invented by Linnaeus and adopted in his Species Plantarum. Koenig, a pupil of Linnaeus, came to the Danish Settlement at Tranquebar (150 miles south of Madras) in 1768 and started with extraordinary energy and enthusiasm, like that of his great teacher, to impart botanical knowledge in Southern India. A society of the United Brothers was formed at that time in order to promote botanical studies in India and three of these brothers—Heyne, Klein and Rottler—were missionaries near Tranquebar. The circle of the United Brothers gradually enlarged and their activities in botanical researches subsequently extended to the Presidency of Bengal where the workers increased to a dozen. The notable members were Fleming, Hunter, Anderson, Berry, John, Roxburgh, Buchanan (afterwards Sir Buchanan-Hamilton) and the famous Oriental scholar, Sir William Jones, the founder of the Royal Asiatic Society of Bengal in 1784.

With the foundation of the Royal Botanic Garden in Calcutta by Col. Robert Kyd, Honorary Superintendent of the then East India Company's garden, in 1787, botanical researches on a proper scientific basis were established in India. Further impetus was added to the botanical activities by the appointment of William Roxburgh, one of the Koenig's United Brotherhood, in 1773 after the death of Kyd. Roxburgh was a medical officer of the East India Company and was posted first in Madras in 1776. Roxburgh explored the flora of the neighbouring area of Samulcotta in North Madras. The results of these floristic

investigations were embodied in three large folio volumes entitled 'The Plants of the Coast of Coromandel'. Roxburgh, with the ample facilities available at the well-equipped institution in the Botanical Garden, Calcutta, assiduously began to work out almost all the indigenous plants of India of which he could procure specimens. Hard labour led to his illness and he was finally forced to leave India in 1813. Within this short period, from 1794–1813, Roxburgh was able to complete the manuscripts entitled 'Flora Indica' and 'Hortus Bengalensis'. He left also magnificent-coloured portfolio drawings, mostly of natural size, of about 2,533 species of plants indigenous to India. These plates embodied in 35 volumes are perhaps the only complete set of its kind in the world. Dr. Roxburgh was thus the first botanist who attempted to draw up a systematic account of the plants of India and his book, which is on the Linnean system, is the basis of all subsequent works on Indian botany; and until the publication of Sir Joseph Hooker's monumental 'Flora of British India' it remained the only single book through which a knowledge of Indian plants could be acquired. He is rightly known as the 'Father of Indian Botany'.

Dr. Buchanan-Hamilton, F.R.S. (afterwards Sir Buchanan-Hamilton), succeeded Roxburgh for a short time, during which period he travelled in Nepal, Mysore and the Burmese kingdom of Ava. He collected a large number of plants which he presented to the University of Edinburgh. In 1817 Dr. Nathaniel Wallich, F.R.S., succeeded Buchanan and undertook with great assiduity extensive exploration work throughout India and Burma. His enormous collections were taken with him and named in Europe by himself and with the help of other botanists. These specimens were then distributed to the leading herbaria of the world. The Sibpur Herbarium also possesses an incomplete set of his collections. A complete set of his collections is now in the Herbarium, Royal Botanic Garden, Kew, in the original Mahogany cabinets prepared by the Linnean Society of London. It is hoped that this complete set of Wallich's specimens will be returned to India in course of time as a result of the revival of exchange relations established by me with the late Sir Arthur Hill, Director, Royal Botanic Garden, Kew. Dr. Wallich during the tenure of his office as Superintendent, Royal Botanic Garden, published his famous 'Plantae Asiaticae Rariores' consisting of three superb volumes of illustrated coloured figures. Dr. Wallich was not only the Superintendent of the East India Company's garden, but also the Professor of Botany at the Medical College, Calcutta, and Superintendent of Teak Plantations in Bengal. Dr. Wallich retired in 1846 after 30 years of service and died in 1854. Wallich's catalogue numbers are the standard numbers referred to as 'Wall-cat.' in all works on the Indian flora throughout the world.

Dr. William Griffith officiated during Wallich's absence on leave. Griffith started his career by botanizing in Tenasserim, South Burma, and his expeditions extended to the Assam valley where he explored Mishmi, Khasia and the Naga Hills. He also visited Bhutan, Irrawaddy and Rangoon and also the Northern Frontiers penetrating to Khorasan at Kabul. He collected also in the Himalayas, particularly in the Simla Hills to the Nerbudda valley in Central India and finally he collected thousands of plants while serving as Civil Surgeon of the Straits Settlements, where he died in 1845 of illness caused by hardships sustained in these places where there were hardly any communications in those days. 'Griffith was a man of genius' and it was Griffith who alone during this period was perhaps the only able cryptogamist in India. He collected and wrote much on *Mosses, Liverworts*, *Marsiliaceae* and *Lycopods* and made hundreds of sketches to illustrate his microscopical observations. His voluminous manuscript was published after his death under the editorship of Dr. McClelland at the expense of the enlightened and liberal East India Company. His posthumous publications were composed of six volumes in octavo, four in quarto including a monograph on Palms. Griffith strongly protested against Wallich's removal of the botanical specimens to Europe and effected return, to our Herbarium, of the Roxburgh's Icones and Wallich's set from England.

The second period starts with the visit to India by Sir Joseph Dalton Hooker. Early in 1848 during George McClelland's period of superintendentship of the garden, Sir (then Dr.) Joseph visited the garden on his famous journey to Sikkim and again on his return to Calcutta. Dr. Hugh Falconer replaced McClelland in 1848 and was succeeded by Dr. Thomas Thomson, M.D., F.R.S., a traveller and a botanist of much ability. Dr. Thomson was the President of the Agri-Horticultural Society (1859-1860), the coadjutor of Sir Joseph Hooker in the collection and distribution of an extensive and well-known herbarium of East Indian plants and the joint author of the first volume of the *Flora Indica*. Thomson retired in 1861 and was succeeded by Dr. Thomas Anderson, M.D., whose untimely death in 1870 was caused by a disease contracted during his effort for the introduction of the quinine-yielding Cinchona into the Sikkim Himalayas. Dr. Anderson was not only Superintendent of Royal Botanic Garden, Calcutta, and Professor of Botany, but also the first Conservator of Forests for Bengal and in charge of the introduction and cultivation of Cinchona in India. For two years (1869–1871) subsequent to Anderson's departure from India in 1868, Mr. C. B. Clarke, F.R.S., an officer of the educational establishments of the Government of Bengal, a well-known systematic botanist and President of the Linnean Society, London, acted as Superintendent and during his incumbency he began a series of botanical publications on his

vast collections of plants. He collaborated with Sir J. D. Hooker in writing the *Flora of British India.* The Sibpur Herbarium received a large number of Clarke's duplicate authentic specimens distributed by Hooker from Kew. These along with others form the present irreplaceable set of the Herbarium.

Sir George King was appointed Superintendent, Royal Botanic Garden in 1871 when the garden, after the great cyclone of 1864, was in a state of great dilapidation. Sir George set about remaking the garden and the present arrangement of the Royal Botanic Garden, Calcutta, the construction of the Herbarium building, residential quarters of the officers, laying out of the lakes and roads were all done during King's time. Sir George, by his voluminous and remarkable contributions, advanced our knowledge of the systematic botany of India and in 1887 initiated the publication noted all over the world, *Annals of the Royal Botanic Garden, Calcutta.* The second part of Vol. XIV of the *Annals* by Prain and Burkill appeared this year. Sir George also moved the Government of India at this time for the establishment of the Botanical Survey of India which originated in 1890. The first issue of the *Records of the Botanical Survey of India* appeared in 1893. Sir George is also the founder of the Lloyd Botanic Garden, Darjeeling, in 1878.

In 1878, in succession to the late Mr. Kurz, the first Curator of the Herbarium and the well-known author of the *Forest Flora of Burma,* Mr. John Scott was appointed Curator. Lt.-Col. (afterwards Sir) David Prain, who was first appointed as Curator of the Herbarium, succeeded Sir George King as Superintendent, the latter after 26 years of meritorious service retired in 1897 but continued his scientific work at Kew. Sir David Prain's valuable publications are well known. His applied aspects of botanical investigation proved to be of considerable benefit to the State. He is now over 80 years old and has just finished his monumental work on the *Dioscoreaceae* in collaboration with Mr. I. H. Burkill, once an officer of the Botanical Survey of India. Sir David Prain, I.M.S., M.A., D.Sc., LL.D., F.R.S., retired in 1906 and was appointed Director, Royal Botanic Garden, Kew, in the same year. Lt.-Col. A. T. Gage, who was first appointed as Curator of the Herbarium, succeeded Sir David as Superintendent in 1906. A catalogue of non-herbaceous phanerogams cultivated in the Royal Botanic Garden, Calcutta, prepared by Lt.-Col. A. T. Gage, I.M.S., C.I.E., was published with the object of facilitating the exchange with botanical institutions of plants, seeds or materials for systematic, anatomical, physiological or chemical investigation. Gage was also Professor of Botany, Medical College, Calcutta. He retired in 1923. During his absence on leave in 1908, Mr. W. W. Smith (now Sir William Wright Smith, Regius Keeper, Royal Botanic Garden, Edinburgh, and Professor of Botany, University of Edinburgh), who was then the Curator of the Herbarium, officiated as the

Superintendent, Royal Botanic Garden, and was succeeded by Mr. C. C. Calder, who retired in 1938 after handing over charge to me. In 1927 Dr. J. M. Cowan, M.A., D.Sc., I.F.S., F.R.S.E., at present Asst. Keeper, Royal Botanic Garden, Edinburgh, officiated in Mr. Calder's place during his absence on leave. Dr. Cowan made some valuable contributions during his work in the Herbarium.

Since the publication of the Annals of the Royal Botanic Garden, Calcutta, in 1887 and the Records of the Botanical Survey of India in 1893, monographs embodying studies on Indian *Pedicularis*, *Magnoliaceae*, *Myristica*, *Orchids* and *Bambusae* were published in the Annals of Royal Botanic Garden, Calcutta, from 1887 to 1900. The contributions made were chiefly by Sir George King, Sir J. D. Hooker, Sir David Prain, Dr. P. Brühl, Messrs. J. Gamble and Robert Pantling. The works published in the Records of the Botanical Survey of India during 1893 to 1900 were mainly on the botanical explorations made by Duthie, Gammie, Marshall Woodrow, Lawson, Prain and Gage. Apart from these, the economic aspects of botany received much attention from the officers of the Royal Botanic Garden and the Botanical Survey of India during the latter part of the nineteenth and first half of the twentieth century. A glance at the first reports and voluminous works of these officers, such as of King, Prain, Watt, Burkill, Hooper and others, indicates the great attempts made by these botanists towards increasing the vegetable wealth of our country in diverse directions, which time and space do not permit me to dilate upon.

It may be emphasized that the results of explorations and subsequent systematic studies of plants collected for experimental cultivation and chemical investigations by the then staff of the Royal Botanic Garden and the Botanical Survey of India led to the introduction and expansion of some of the most important economic plants. Of such plants may be mentioned cotton, tobacco, jute, tea, flax, hemp, rheea, henbane, vanilla, sarsaparilla, coffee, cocoa, ipecacuanha, aloes, jalap, India-rubber, Japanese paper-mulberry, cardamoms, tapioca and many others. The Forest and Agriculture Departments may also be said to have their origin from the Royal Botanic Garden, Calcutta. Development of the forest products by the Forest Department had its first inception in Bombay in 1807. This scheme was, however, abandoned in 1822. It was, however, resumed during 1839-1840. It was then developed more or less on scientific basis by Dr. Gibson as its first head in the Presidency of Bombay.

The creation of the post of the Reporter of Economic Products in 1883 and the appointment of Dr. George Watt, afterwards Sir George Watt, as first incumbent, led to considerable progress in the advancement of our knowledge of economic plants of India, Burma and Malaya. Sir George's compilation of the well-known Dictionary of Economic Products and the

establishment of a magnificent Museum of Economic Products in Calcutta, now the Industrial Section, Indian Museum, are his great achievements. The Dictionary of Malayan Economic Products by his successor, the able botanist, Mr. I. H. Burkill is an almost equally valuable contribution.

The introductive success of cinchona exotic, cotton, tea, coffee, cocoa, jute is too well known to recapitulate here. The appointment of Sir Dietrich Brandis as Inspector-General of all the Government Forests in British India at about this time and the subsequent establishment of the Imperial Forest Research Institute at Dehra Dun initiated rapid progress towards our further knowledge of forest trees and their scientific exploitation. The science of forestry is intimately linked with the systematic and taxonomic studies of plants. In fact, modern forestry presupposes a sound knowledge of systematic botany. Dr. King rightly remarked in his concluding para., 'It is not because I like to play the censor that I have made these remarks about the Forest Department. Having myself served in it from 1869 to 1871, I can speak from my own experience as to the value, from the utilitarian point of view, of a knowledge of the names, affinities, and properties of the trees, shrubs, and herbs which compose an Indian jungle, and a knowledge of these as individual members of the vegetable kingdom rather than as masses of tissue to be studied through a microscope. The appointment which I held in India for twenty-six years after leaving the Forest Department gave me full opportunity of getting into touch with all who interest themselves in a knowledge of plants, and of discovering how few of these at the present day are Forest Officers. The majority of the latter, if they love their trees, are content to do so without knowing their names or relationships! There are, of course, splendid exceptions who know as well as love.' Nevertheless, the conditions have, during the course of the last 50 years, improved to a certain extent and although there are such brilliant systematists as H. H. Haines, who was appointed as the first Forest Botanist in 1906, U. N. Kanjilal, R. S. Hole, R. N. Parker, C. E. Parkinson, J. M. Cowan, C. E. C. Fischer and the two distinguished past Presidents of this section, H. G. Champion, at present of the Oxford University and Dr. N. L. Bor of Assam, much remains yet for the Forest Officers to make up their deficiencies in this important aspect of botanical knowledge so essential for the study of the various problems associated with the scientific exploitation of our vast forest areas.

A glance at the work from 1900 to 1940 shows that a considerable amount of work has been done in the systematic and taxonomic studies, particularly of Eastern India, Western India, South India and to a certain extent North-Western India, mainly by the officers of the Royal Botanic Garden, Botanical Survey of India and botanists of the Imperial Forest Research

Institute. Since the publication of the Flora of British India from 1895 to 1907 about 2,000 species of Indian plants have been added up to date. The total number of species of Indian Phanerogams as noted in Hooker's flora is about 13,500 to 14,000 and the total up to date would be approximately 16,000 species. The number of genera new to India, either added or recorded since the publication of the Flora of British India, may be estimated at 300. About one dozen local floras, namely, Punjab Plants by Stewart (1869), Flora Simlensis by Collett (1902), Bengal Plants by Prain (1903), Cook's Flora of Bombay Presidency (1903–1908), Duthie's Flora of the Upper Gangetic Plains (1903–1929), Asiatic Palms by Odoardo Beccari and subsequently with U. Martelli (1908–1931), Flora of Madras by Gamble and Fischer (1915–1936), Flora of the Nilgiris and Pulney Hill tops by Fyson (1916–1920), Forest Flora of the Punjab by Parker (1918), Haines' Flora of Bihar and Orissa (1922–1925), Flora of Assam by Kanjilal, Das, De and Bor (1934–1940), Water and Marsh Plants of India and Burma by Biswas and Calder (1936), Wild flowers of Kashmir by Coventry (1925–1930), Beautiful flowers of Kashmir by Blatter (1916) and quite a large number of monographs, handlists, catalogues and notes on the botanical explorations of the different parts of India have also been published in the Annals of the Royal Botanic Garden, Calcutta, the Records of the Botanical Survey of India, Hooker's Icones Plantarum, Kew, Kew Bulletin, Fedde's Repatorium, Notes from the Royal Botanic Garden, Edinburgh, Journal of the Bombay Natural History Society, Journal of Botany, London, Journal of the Indian Botanical Society, Forest Records, Indian Forester, Journal of the Royal Asiatic Society of Bengal and elsewhere. Indian botanists who are now engaged in systematic botany are confined mainly to the Government institutions in Calcutta and Dehra Dun. Very few members of the staff of the universities in our country take sufficient interest in systematic and taxonomic researches. This paucity of systematic and taxonomic workers among the staff of universities may be ascribed to devoting their energy and attention to their academic work and such aspects of botanical researches as can be better undertaken in their laboratories. Prolonged field work at different seasons and subsequent attention to and determination of the plants collected on a mass scale are neither within the normal spheres of their activities nor have they sufficient time and facilities required for systematic and taxonomic work on a proper scale. Their investigations in the laboratories are by no means less important in solving many an intricate problem in systematic and taxonomic studies as revealed in the modern trend of systematic researches.

Apart from the little floristic investigation in some parts of India, there still exist vast unexplored and insufficiently explored regions (see Map of India showing the explored and

unexplored regions). Then again, the provinces which have received attention so far are not complete enough. Among the

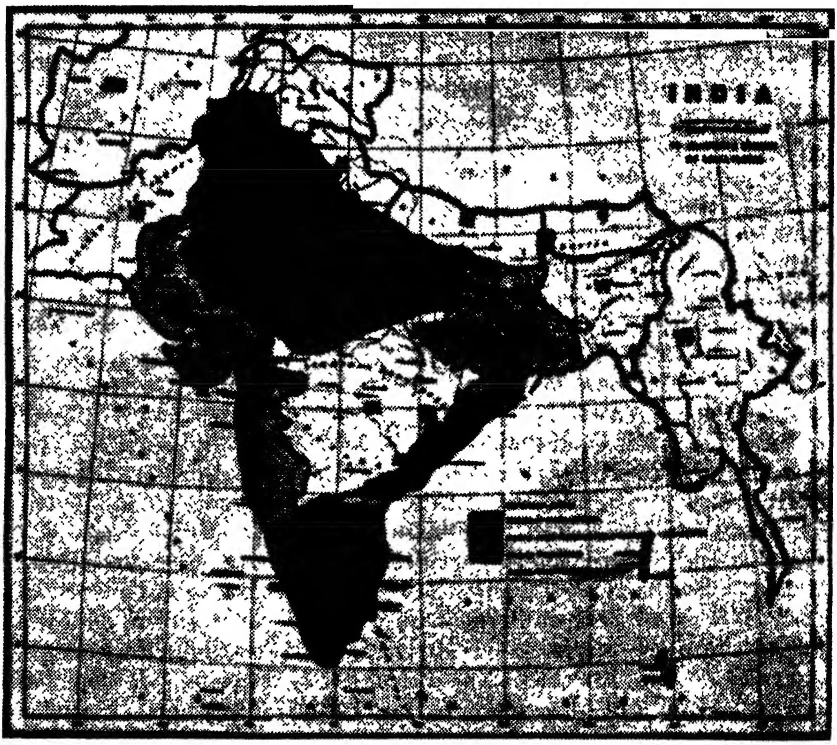


FIG. 1. Map of India and Burma showing the Phytogeographical Divisions of India with the explored, unexplored and insufficiently explored regions.

areas which are unexplored and imperfectly explored may be mentioned the borders of Bengal and Assam, Mysore, Hyderabad, practically the whole of Central India including Central Provinces and Berar, large forest tracts of Rajputana, the extreme borders of the Punjab and United Provinces particularly the Kumaon hill ranges of the Western Himalayas, Kashmir, Nepal, Sikkim, Bhutan and Burma. Comprehensive local floras of these areas are long overdue. Moreover, it is mostly the trees and shrubs that have received attention. The large herbaceous and under-shrubby vegetation, not to speak of the enormous cryptogamic flora, remains still to be tackled even in the so-called botanically known areas. The study of these as well as of the lower plants is of considerable value in agriculture, forestry, plant genetics, plant breeding and horticulture. A sufficient knowledge of the life-histories of the lower plants

is of great importance in the study of ecology, biology, malariology and soil science. Studies of plants collected as a result of explorations, from the Eastern Himalayas, borders of Bengal, Assam, Nepal, Bhutan, Tibet, Yunnan and from North, Middle and South Burma and Thailand in the Far East, throw a flood of light on the various elements in the Indian flora and the geographical distribution of the species comprising the various types of vegetation in these lands. Among the recent collectors of plants from Eastern India mention may be made of P. Brühl, David Prain, G. H. Cave, P. T. Russel, Ribu and Rhomow, F. E. Younghusband, G. Forest, J. F. Rock, L. Dudley Stamp, W. W. Smith, I. H. Burkill, U. N. Kanjilal, H. G. Carter, A. T. Gage, C. E. Parkinson, J. B. Gould, R. E. Cooper, Mrs. N. E. Perry, J. M. Cowan, the members of the Everest Expedition, F. Ludlow, G. Sheriff, K. Biswas, N. L. Bor, Sir John Anderson, Mrs. Craker, Mrs. H. P. V. Townend and last, but not the least, that famous plant hunter, Kingdon Ward. The general features of the vegetation, which I have been able to study during the period of my botanical career in the Royal Botanic Garden, furnish also valuable data with regard to the taxonomy, geographical distribution, ecology and biology of the various plant communities in the different parts of Eastern India and Burma. A sketch of the vegetation from the sea-shores of Bengal and Arakan extending to the extreme borders of South Burma and to the higher regions of the Northern Bengal, Sikkim, Bhutan and frontiers of Assam and Burma, Himalayas illustrates the general features of the different types of plant communities under different ecological conditions. The floristics of these areas are at present receiving my special attention.

Mangrove Vegetation.

The mangrove formation along the estuarine regions from the Sundribuns via Chittagong and Arakan to the Mergui coast line is composed of several pure and mixed associations of mangrove species. In some portions along the creeks typical 'Rhizophora mangle' forms the characteristic littoral vegetation in which ***R. mucronata*** is the dominant species. In other places one observes ***Avicennia***, ***Nipa*** and ***Aegialitis*** associations (see figs. 2 & 3). The mixed association of mangrove vegetation in this area is composed of the following species: ***Rhizophora mucronata***, ***Nipa fruticans***, ***Avicennia officinalis***, ***A. alba***, ***A. tomentosa***, ***Phoenix paludosa***, ***Ceriops Roxburghiana***, ***Bruguiera gymnorhiza***, ***Sonneratia acida***, ***S. apetala***, ***Kandelia Rheedii***, ***Aegiceras majus***, ***Carapa obovata***, ***Excoecaria Agallocha***, ***Acanthus ilicifolius***, ***Acrostichum aureum***, ***Aegialitis rotundifolia***, ***Suaeda maritima***, and others.

The algal associations in the mangrove regions are also characteristic. The perennial plankton association is chiefly

composed of various blue-green and a few green algae. The most common species are *Microcystis aeruginosa*, *Oscillatoria*

FIG. 2. Mangrove swamps showing the Rhizophora mangle in the Sundribuns.

(Reproduced by courtesy of Bomb. Nat. Hist. Soc.)

princeps, *O. laetivirens*, *O. salina*, *O. amphibia*, *O. tenuis*, *Phormidium tenue*, *Spirulina major*, *Anabaena spiroides*, *A. flos-aquae*, *Microcoleus chthonoplastes*, *Diatom Sp.*-*Synedra affinis* and large floating masses of *Enteromorpha intestinalis* and *prolifera*. Some of these are found in the gut contents of the edible fishes of those waters. Crustaceous communities of the red algae *Caloglossa Leprieurii*, *Ceramium gracillimum* and *Catenella Opuntia* are abundant. Straggling communities of *Lyngbya majuscula*, *Chaetomorpha Linum*, *Enteromorpha intestinalis* and *Rhizoclonium riparium* growing on various substrata lie within the tidal zone. Brick-red to brown slimy masses of iron bacteria composed mainly of *Leptothrix ochracea* are seen in patches here and there. Muddy flats often covered with thin films of *Synedra affinis* and a few other Diatoms in the Sundribun region and South Burma and Malaya extend over several miles along the sides of creeks and estuarine rivers and foreshores of inland salt-lakes such as at Ennur in Madras and Port Canning near Calcutta. These localities are rather unhealthy as the soft,

deep, bluish mud exposed to the action of tides with the background of a typical vegetation is full of rotting and stinking

FIG. 3. Nipa association in the Sundribuns with Avicennia and Sonneratia in the background.

(Reproduced by courtesy of Bomb. Nat. Hist. Soc.)

organic bodies infested with putrefaction bacteria. The Indo-Malayan element is predominant in the littoral flora in these parts of the coast line of Eastern India.

VEGETATION OF THE RAIN FORESTS IN EASTERN INDIA AND SOUTH BURMA.

Penetrating into the interior as one crosses the forests of the Chittagong Hill Tracts along the frontiers of Assam and Burma, the bamboo association intermixed with cane gradually merges into the rain forests which reach their full luxuriance further down in the South Burma country bordering Thailand (Siam) and Malaya. The Tropical Rain Forests of South Burma have a striking similarity to those of the Chittagong Hill Tracts and Arakan sea coasts (see fig. 4). In fact, the same type of forest gradually runs down along the Arakan sea coast and finally extends to the Malay Peninsula through Mergui and Tenasserim differing only in its luxuriance and

density and particularly in their evergreen and mixed nature due to local variation in climatic and edaphic factors. Towards

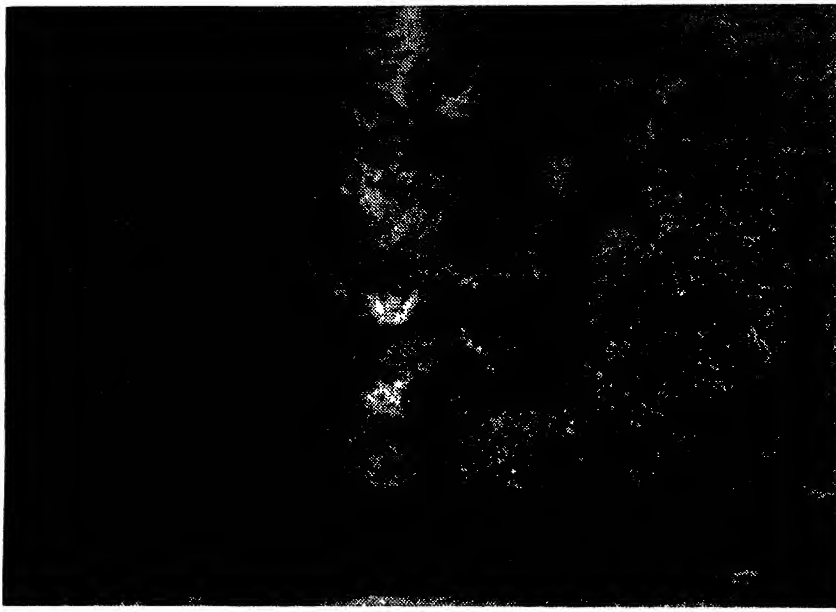


Fig. 4. The dense Primeval Rain Forest with the four storeys of vegetation on either sides of a narrow hill stream along the borders of Tenasserim (Mergui, extreme South Burma) and Thailand (Siam).

(Photo by K. Biswas)

the Chittagong and Arakan areas the vegetation is of a mixed deciduous and evergreen type and further down in Mergui and Tenasserim it takes on a more evergreen character.

During secondary formation there is the same tendency of the plants to develop into a tropical rain forest in which Bamboos and Canes claim supremacy, although in some places *Blumea balsamifera* gains in the beginning an upper hand but soon it is overtopped by bamboos. Thus in some of the most frequented areas, as noticed on the Moulmein hills of the town proper, *Bambusa polymorpha* is a dominant species growing in dense thickets. The other shrubby species—such as *Connarus paniculatus*, *Congea tomentosa*, *Melastoma malabathricum*—form a mixed association in more open areas. Along the slopes—*Sterculia villosa*, *Chaetocarpus castanocarpus*, *Ficus* species and other trees and shrubs indicate that they are the members of the Tropical Rain Forests.

In the Kyeinchaung forest areas of the Cinchona Reserve, an uncharted country in Tenasserim, Mergui district, extreme South Burma, I came across the characteristic dense mass of

vegetation of the virgin Tropical Rain Forests covering shady valleys and the slopes of low ranges of hills extending towards

FIG. 5. Forests of hill tracts along the borders of Bengal and Assam showing the nature of vegetation in which Bamboo predominates as a result of Jhooming (Taungya) seen in the foreground with the Bamboo association in the background near the elephant.

(Photo by K. Biswas)

Siam in the north and Malaya in the south. Here lofty trees shoot up from an impenetrable crowded mass of bamboos and cane brakes.

In moist and darker portions of the forests broad-leaved palms and Cycas are found scattered here and there, and in some places groups of *Licuala peltata, Zalacca Wallichiana, Cycas Rumphii* and herbaceous Scitamineae species are not infrequently met with.

Thus, the vegetation of these primeval forests may be subdivided into four strata. The highest storey consists of tall species of *Dipterocarpus, Ficus, Dillenia, Stereospermum, Sterculia, Lagerstroemia, Parashorea* and others forming a canopy over the next tier of mixed bamboo and cane brakes. This central zone of mixed bamboos and cane brakes interlocked with rattan is chiefly composed of several species of bamboos, such as *Bambusa arundinacea, Bambusa polymorpha, Oxytenathra albo-ciliata, Dendrocalamus strictus* and others.

Associated with these bamboos and canes are also found smaller trees, shrubs and tall herbaceous species, such as

Barringtonia acutangula, *Grewia Microcos*, *Streblus asper*, *Randia species*, *Croton species*, *Ixora species* and also a few species of palms noted above. This stratum again gradually dwindles down to the low shrubby and herbaceous members, namely, *Alpinum sp.*, *Curcuma sp.*, *Strobilanthes sp.*, *Jasminum sp.*, *Coffea bengalensis* and smaller plants of *Gnetum sp.* (the young leaves of *Gnetum edule* are a favourite vegetable diet of the Burmans). Finally, this zone of herbaceous association gradually ends in the floor vegetation of low diffused herbs and trailers which in some places appear as mosaic carpets on the ground. Pure grass mats are extremely rare inside these forests. Tall lianes, scandent shrubs and climbers, such as *Bauhinia sp.*, *Butea superba*, *Vitis sp.*, *Entada scandens*, *Zizyphus oenoplia*, *Mucuna sp.*, *Ipomaea sp.*, and others, are found intertwined with bamboos or overhanging like festoons from taller trees. Along the banks of the Kyein-chaung river the spreading shrubs of *Homonia riparia* are commonly met with in the forest. Epiphytic orchids, such as *Dendrobium densiflorum*, *Dendrobium Pierardi* with their long drooping bunches of beautiful flowers, and numerous plants of the most common epiphytic fern—*Asplenium nidus* in its full grandeur, adorn the branches and stems of trees often covered with thick pads of tropical species of mosses. *Rhaphidophora pertusa* and *Pothos scandens* are often seen climbing up to a considerable height on the trunk of sturdy trees. The thicker leaves of the herbs and shrubs in the interior of the forests have their margins fringed with mossy outgrowths and leaf surfaces are often studded with numerous epiphyllous lichens. Mention may specially be made of a magnificent specimen of nest epiphyte—*Platycerium grande* (the staghorn fern)—well known for its large pocket leaves and pendulous dichotomous foliage leaves. This interesting fern, which is reported here for the first time from Mergui, South Burma, is a native of Malay Peninsula (as recorded by Schimper) and has evidently found its way into Lower Burma as well.

General Features of the Vegetation of the Eastern Himalayas.

The Sikkim and Bhutan hill ranges lie in that part of Asia where the three great areas, China, India and Tibet, are very close together. Geographical factors seem to have resulted not so much in comparative isolation, but in lack of opportunities for interpenetration, since the huge mountainous range of the Himalayas separates India from Tibet and the sheer gorges of the Irrawaddy, Salween and Mekong rivers, with their wellnigh uncrossable divides, effectively bar communication for man at any rate between India and south-west China. Even so, these three areas have distinctive peoples, climates, plants and animals, but types appear in common and tend to intermingle occasionally where the boundaries of the areas march

together. The Eastern Himalayas are roughly bounded by Nepal on its west flank, Tibet on the east and north, and Assam and Bengal on the south.

Part of the main Himalayan range, the Indo-Tibetan divide, forms the northern boundary of the country, and its big snow-covered groups of peaks reach, at their highest points, elevations of 20–23,000 feet. From this main range a series of ridges run southwards, decreasing in elevation until they reach the plains of India; but where they cross the line of 27° 30′ N. lat. there is a noticeable tendency for many of these ridges to throw up their crests in peaks varying from 14,000 feet to nearly 17,000 feet in altitude. Lateral spurs project with an easy slope into the valleys, but sometimes the slopes make an abrupt descent to the bottoms of the valleys from shoulders at elevations of 8–9,000 feet.

Eastward from the line of 91° E. the configuration of the Himalayan chain alters. No longer do the secondary ranges trend southward from the main divide. This itself shows signs

Fig. 6. The mixed association of the typical temperate rain forests of Acer-Quercus-Betula-Tsuga-Rhododendron and Rosa association in the frontiers of Bhutan and Sikkim.

(Photo by K. Biswas)

of disintegration, and the secondary ranges begin to stretch from broken sections of it in other directions. The observable

tendency is a swinging to the north-east and south-west, a changing of direction which culminates in the direct north and south trend of the divides of the big Assam and Burmese gorges.

The character of the vegetation is influenced by the strong, moisture-laden, monsoon winds from the south. The ramifying outer spurs have a heavy rainfall, and are densely clad by moist forest of tropical and sub-temperate genera. The central portions of the gorges and valleys have a lesser rainfall and tend to bear a drier type of forest. The moisture-laden breezes of the upper layers of the atmosphere pass unscathed over the outer spurs, only to be arrested by the summits of the ridges in the interior, where in consequence they deposit their moisture and a moist temperate flora develops. This is made up of moss-clad and lichen-draped Rhododendrons, Maple, Poplars and Birches. The general features of the vegetation are illustrated in figs. 6, 7, 8 and 9. Higher up between 10,000 to 11,000 is seen Abies densiflora, Rhododendron and Rosa association. (See fig. 7.)

FIG. 7. Abies-Rhododendron and Rosa association above Tonglu (Eastern Himalaya) towards Sandakphu. Elevation—11,000 to 12,000 ft.

(Photo by K. Biswas)

Trees range up the slopes to an upper limit of approximately 13,000 feet, with a dense undergrowth of shrubs and bushes,

but there are many open glades containing herbaceous plants only. Above 11,000 feet—the altitudinal limit of Pines—Spruce and

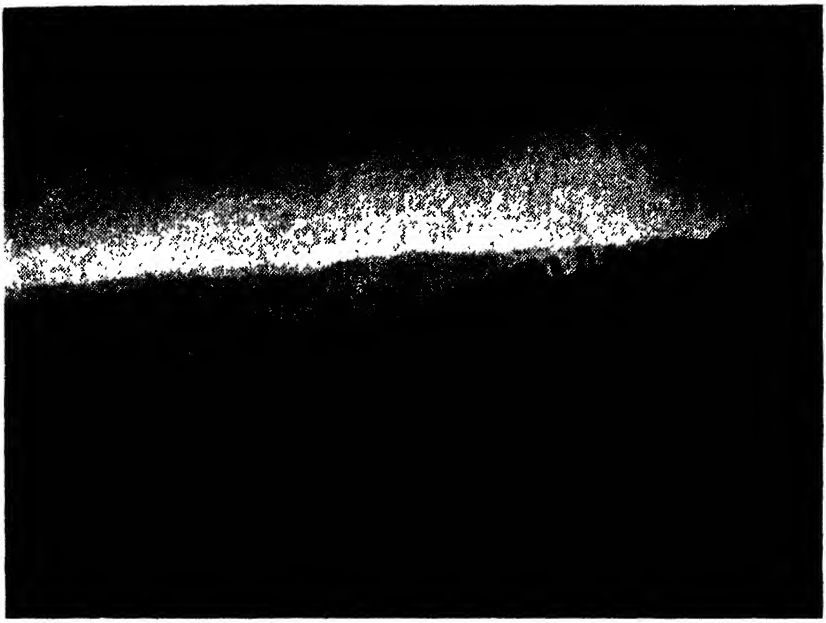


FIG. 8. The sparse dwarf vegetation of bushy Rhododendron and Gaultheria at about 12,000–13,000 ft. with the Mount Everest in the background as seen from Sandakphu. Elevation—12,000 to 14,000 ft.

(Photo by K. Biswas)

Juniper are found, mainly on moist and dry slopes respectively and range to the limit of tree-growth. (See figs. 8 & 9.)

Above tree-level, where the slopes are moist, they bear a rich moisture-loving flora of biennial and perennial dwarfish herbaceous plants. Those uplands, which are robbed of moisture by intervening peaks and ridges, are consequently drier and have a less profuse herbage, all forms showing adaptations to drought, and also response to the effects of high altitudes. These areas are free from snow only from April to September, and this short season, during which alone growth is possible, seems to generate a definite type of plant which produces flower spikes at the first awakening of growth, the leaves following immediately after. The climatic conditions of the drier upland valleys are coincident with those prevailing on the north side of the main chain (*i.e.* in Tibet), and plant forms range accordingly across the chain into that country. The altitudinal succession of vegetation is shown in the following diagram (fig. 10, page 121).

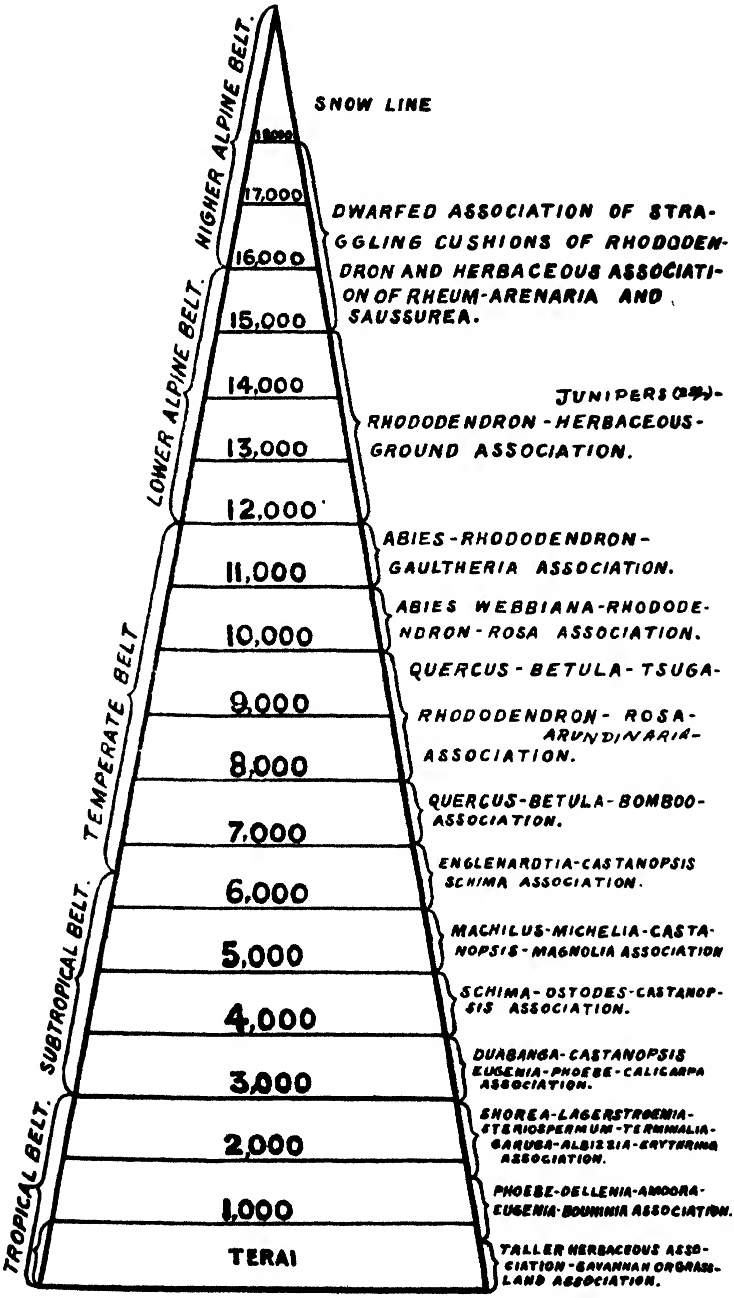
Recent discoveries of a large number of new species from South-Eastern Tibet, east borders of Assam, Bhutan and Upper

FIG. 9. Stunted Rhododendron and Betula utilis and dwarf shrubs and herbs above the tree limit beyond Phalute close to Kanchinjunga range with the Mount Kanchinjunga in the background. Elevation—11,800 to 13,000 ft.

(*Photo by K. Biswas*)

Burma need not cause any surprise because the Bhutan Himalaya and its extension eastwards as far as the frontiers of India and beyond across the river gorge country are all still mostly *terra incognita* botanically, except for the travels of William Griffith at the beginning of the last century and the recent travels of I. H. Burkill, R. E. Cooper, Kingdon Ward, F. Ludlow and G. Sheriff, J. Anderson and K. P. Biswas.

Collections of Smith, Cavé, Burkill, Bor, Biswas, Gould, Kingdon Ward, Ludlow, Sheriff and others in the extreme borders of Bengal, Assam and South-Eastern Himalaya lead to several hypotheses regarding plant distributions. The exploration in South-East Tibet along the Salween-Irrawaddy divide, Shugdan Gompa, Dri valley, Delei valley and part of the Mishmis by Kingdon Ward and his observations on the floristics of Tibet and the frontier of Northern Assam, Burma, Yunnan and Szechuan are of particular interest. He has attempted to indicate that the affinity of the Eastern Himalayan flora lies almost entirely with Western China across the Tibetan



ALTITUDINAL SUCCESSION OF VEGETATION.

FIG. 10.

river gorge country. It does not lie with the southern ranges except in a minor degree, although the mountain ranges appear to be continuous in this direction. Both Alpine flora and temperate forest flora in this region of the Tibetan Himalaya extend to the east and west in continuous belts. Definite zonal vegetation according to altitude exists at this spot where temperate rain forest begins, ending with Alpine flowers and the characteristic dwarf, shrubby vegetation in the higher zones. It is evident from his review, as well as previous contributions and collections of plants, that the flora of Tibet becomes progressively richer and more varied as one travels south-eastwards into the river gorge country where many types of plant associations are met with. The river gorge country in this part of the Himalayan ranges can certainly be called one of the richest botanical treasure-houses of the world.

The Abor area in Northern Assam seems to be a particularly suitable one for the study of questions concerning the ecology and geographical distribution of plants. The Abor land which was explored by I. H. Burkill during the months of November to March 1911-12 and his field observations and collections prove to be of high scientific value. The Abor land forms the meeting point of several very distinct types of flora all of which are carefully analyzed by the author in his flora of the Abor Expedition. The result of his studies throws a flood of light on the origin of the flora, its history and its relationship. The biology of the flora of the Abor land and various ecological associations, the chief of which are the Skingkeng association and the genesis of the flora, are of considerable value to botanists interested in the plants of this area.

Reference to the collections of plants from the Garo Hills shows also a relationship which exists between the Garo Hills and the Eastern Himalayan region. It is interesting to observe that while the old conception that the region of the Sikkim Himalaya harboured the matrix of several important groups of plants of a common Eastern Chinese and North-East Indian distribution has had to give way to the claims of the region further east, separating Burma, Assam and Szechuan to represent both sections, the Garo Hills, lying south and detached from the main line of geographical distribution, tend rather to the Western than to the Eastern complement. Although much remains to be explored before an area representing the most natural meeting ground of these Asiatic floras can be fixed, it is certain that, to a fuller understanding of the problem of group distribution, an intimate knowledge of such detached areas as the Garo Hills furnish will be essential. To link up the evidence from this part of the world exploration work in detail needs to be undertaken in the rich floristic areas of Northern Burma and Szechuan. Such an exploration would also provide material for an ecological analysis.

Different Elements of the Indian Flora.

Mr. Calder reproducing more or less Sir Joseph D. Hooker's theory regarding the different elements of the Indian flora states, 'Of the elements of the flora of India, the Malayan is dominant. This undoubtedly arises from the fact that the barriers set by climate and by the high uplands and mountainous frontiers to the infiltration of plants from the north and north-west are absent from Malaya. The sea is a still more effective barrier so that the African and to a still higher degree the Australian and American elements are less well represented than the European and Middle East floras. No fewer than 570 European genera figure in the Indian lists, many of them, however, represented by a single species, and the Middle Eastern element is certainly, as is to be expected, not less prominent. How far the European plant element in India may be considered as native is a subject of speculation, but the recent influx of American species taken with their marked tendency to spread makes it possible to suppose that modern transport has been an agent and that before the era of Indian botanical work a considerable European element had by this means managed to reach and establish itself in this part of the world. It is curious that although the Tibetan and Siberian floras reach India in the Alpine regions of the Himalaya, the Chinese and Japanese floras are strongly represented in its temperate belt.'

'An examination of the flora of India shows the outstanding peculiarity that no one of the families of flowering plants is peculiar to it, and if the genera common to India and some adjacent countries be excluded few endemic genera remain, and such of them as are endemic are local and with few exceptions are restricted to one or few species. When, therefore, the immense range of conditions that India presents for plant life be considered, it is an enigma that its flora can yet be considered as merely an aggregation of several floral types.'

In this statement Calder has not evidently taken into account the recent additions to the Indian flora under different classes of the plant kingdom. The subject of the composition of the Indian flora as sketched by Hooker and C. B. Clarke and hitherto adopted by botanists needs drastic change in the light of our knowledge of the geographical distribution of the species occurring in India and recent further discoveries of numerous species, during the course of the last forty years. Systematic researches on ferns and fern allies, mosses and liverworts also throw some light on the question of endemism in the Indian flora. Such modifications were anticipated by Sir David Prain who in a circular letter, while distributing Hooker's 'Sketch of the Flora of British India' to the then systematists, noted, 'The accompanying sketch of the flora of British India by Sir Joseph Hooker is issued in an advance form, subject to revision, with

the request that you will kindly peruse it and make any addition or correction that may strike you as called for with regard to the vegetation of those parts of India with which you are more particularly acquainted.'

Although there is some difference of opinion among the workers with regard to the Indian elements, most of the recent botanical explorers and systematists hinted in their works at the presence of a sufficient number of endemic plants in the flora of India. Prof. Kashyap, while discussing some aspects of the Alpine vegetation of the Himalaya and Tibet, differs from others in regard to the origin of the flora of Western Tibet. He remarks that 'some people have given Central Asia great importance in connection with the origin of the Alpine plants. Arber states, "It has been urged that Central Asia was the origin of the Alpine flora." Hemsley says, "No arguments are required to prove that the Tibetan is a derived flora; that is to say, derived since tertiary period; and its composition is so largely Himalayan that there can be little doubt as to its origin." This would seem to imply that Tibet was bare at some time when the Himalaya was covered with vegetation. The high altitude of Tibet makes this very improbable. The upheaval of the Himalayas and Tibet must have been simultaneous and the vegetation also must have developed simultaneously. Marquand very recently has remarked, "Material available now makes it quite clear that one homogeneous flora extends from Sikkim to Eastern Tibet and the whole of the Eastern Himalayas, South-Eastern Tibet and Western Szechuan as well as upper portions of Yunnan should be considered as one botanical area." Central Tibet is not sharply marked off from Eastern Tibet with its more luxuriant vegetation on the one hand and from the higher and wilder Western Tibet with its scanty vegetation but it cannot be said that the flora of Western Tibet has had a different origin. It possesses a smaller number of plants, more highly adapted to more unfavourable conditions than their eastern relatives. The flora of Western Tibet must naturally be poorer as fewer plants can be expected to adapt themselves to extreme conditions'.

'Considering all the data it would be more in accordance with facts to say that the floras of the Himalayas and Tibet and Western China have had a common origin and differentiation gradually took place as the Himalaya and the Tibetan plateau gradually rose from the sea-level to become the highest region in the world.'

Capt. Kingdon Ward in his discussion on 'An outline of the vegetation and flora of Tibet', however, holds that 'the present flora of Tibet is not an indigenous flora; it has been almost entirely derived from the surrounding regions. The arrangement of the mountain ranges which completely encircle the plateau, and the former great extension of the Himalayan, Chinese and Eastern Tibetan glaciers prove that during the Pleistocene

glaciation the plateau was surrounded by a belt of ice which must have almost completely sterilized any pre-glacial flora it possessed. Whatever that pre-glacial flora may have been, little, if any, of it survived the Ice Age. Since the restocking of Tibet, the flora has probably undergone little modification'.

Sir David Prain, on the other hand, admits that a detailed review, so far as concerned the N.W. Himalaya and Sikkim, is likely to prove incomplete owing to our rather partial acquaintance with the flora of the region between Garhwal and Sikkim and our most imperfect acquaintance with that of the region between Sikkim and the Mishmi country.

'It seems to me therefore,' adds Sir David Prain in a letter to me, 'that the time can hardly yet be ripe for a discussion on the origins of the flora as a whole; one must, I think, say origins in the plural number because we do know already that there are links between the Himalaya and Peninsular India, between the Himalaya and Persia, between the Himalaya and Central Asia, between the Himalaya and China even between the Himalaya and Japan, also that it is a point which has been in dispute as to the boundary between the Himalaya and Tibet.'

Sir W. W. Smith is of opinion that 'the distribution of the flora is so wide a theme that I think in your place I should bring it down to a few general statements. In the extreme North-West you have an undoubted connection with the flora of the Orient especially with Persia. At the other end you have a marked relationship, especially as regards genera, with the mountains of West China, and to a much lesser extent with Burma. The association with Burma is really an explanation of the Chinese association. As for the intermediate region, its genera are in the main members of what may be called the palaeoarctic group. This would be true of most of the flora above 7,000 ft.' 'Your own collected data,' writes Sir William to me, 'on the flora of the Himalaya will give you my own point of view and I think the matter may very safely be left in your hands.'

Bor, in his observations on the flora of the Naga and Khasi Hills, remarks that 'the discovery by Hooker of terminal moraines in Sikkim at an altitude of 2,300 m., where at the present day no glaciers are found below 4,600 m., suggests that during the glacial epoch the mountains of the Himalaya which are now forest clad, must have been covered with snow. The Naga Hills may very well have been in the same condition. The Bhabar tract in Goalpara and Darrang consists of enormous boulder deposits of Pleistocene age which indicate that even the plain may have been too cold to support such a flora as is now found in the Eastern Himalaya at high altitudes.

'The immediate result of the glacial epoch would have been to eject the pre-glacial flora of the Himalaya to the south where there was sufficient warmth for it to exist. The retreat of the ice would see the return of an Indo-Malayan flora, the advance

of which was facilitated by the mountainous country which lay to the south and south-east. If this theory be correct, one would expect to find a general resemblance in the floras of the Eastern Himalaya, Naga Hills and Khasi Hills.' This seems to be true to a certain extent also with regard to the flora covering the top of the ridges of the Pareshnath Hill, the highest mountain in the Santal Parganas along the border of Bengal and Bihar. Here at an elevation of 4,000 ft. the flora is, as observed by me and indicated by Anderson, almost similar to that of the Eastern Himalaya as found particularly in the region of Kurseong in the Darjeeling district.

Chatterjee, in his recent investigation after a thorough survey of the Dicotyledonous species of India and neighbouring areas, points out clearly that the number of endemic species common generally in India is 533, in the Himalayas 3,165, in Continental India 2,045 and in Burma 1,076. Dr. Chatterjee's

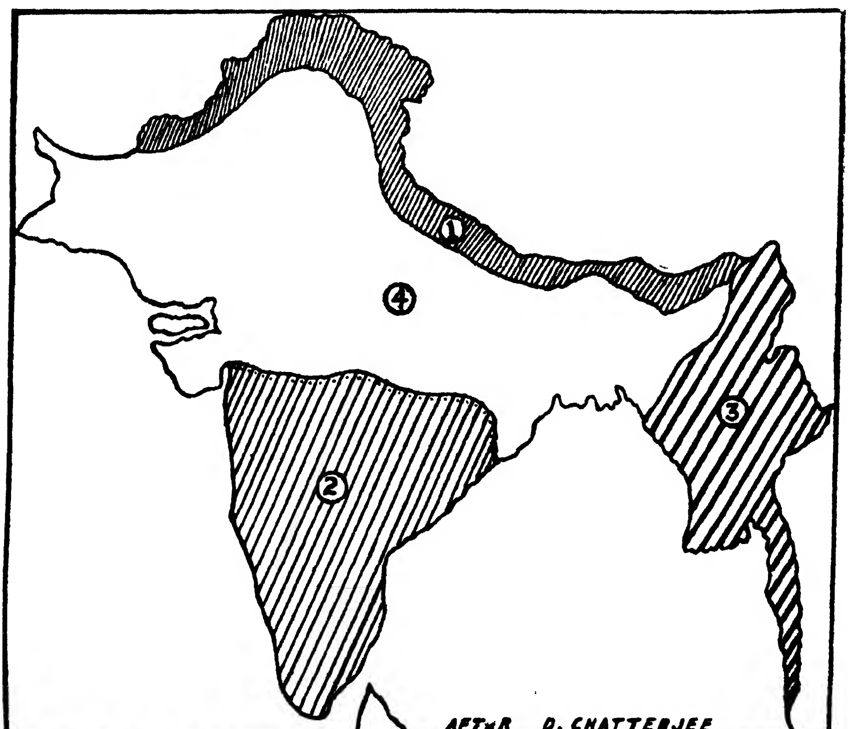


FIG. 11. Map showing divisions of India according to endemic values. Shaded areas, (1), (2) and (3), show the degrees of endemicity in different parts. (4) represents area of low endemism.

researches thus reveal that the view held by Hooker and followed hitherto by others is not quite correct. According to

Dr. Chatterjee's estimate 61·5% of the plants are endemic. 'This figure,' he adds, 'is definitely very high for a continental area with land connection in three directions—east, north and west. In India there are three regions containing a specially high percentage for the whole country. These regions are: (i) the Himalayas, (ii) the Indian Peninsula forming "Continental India", and (iii) Burma. The rest of India—the Indo-Gangetic plains and the desert regions of Sind, Rajputana and the dry regions of Baluchistan—form an area which is extremely poor in endemic content.' The variation of the intensity of the endemic population is delineated in his map (see fig. 11).

He further explains that 'it is clear from the map that the northern part of India is completely occupied by the lofty mountains of the Himalayan range. The effective nature of this as a barrier to plant-migration has already been pointed out. This barrier is separated from continental India by a broad and dry plain which has cut off that region from close contact with the northern flora, thus affording a large independent area with a high endemic population. The Deccan Peninsula contains no less than 2,045 endemic species and is thus not far behind the Himalayas with 3,169 endemic species. How far land connections between Malayasia, India and Africa have influenced the present flora of the Deccan Peninsula is difficult to indicate with any degree of precision'.

My rough analysis of the flora of the Sikkim Himalaya in and about the town of Darjeeling, both wild and cultivated species, shows that nearly 50% of the total number are indigenous to the Himalayas. The rest of the plants under cultivation in Darjeeling are composed of foreign species of which Japan represents about 14%, North America 7%, Australia 6%, China 6%, Malaya 4%, Europe 4%, South America 3%, Tropical Asia 3%, Central America 2%, Burma 1% and Africa 0·5%.

The results of the study of the Phanerogamic flora of Eastern India, a brief sketch of which has been given above, definitely establishes a high degree of endemicity in the flora of India as far as can be judged from living flora. The analysis of the various classes of the Cryptogamic flora shows, however, slight variation in the endemic values as outlined by Chatterjee. Of the Filicales, out of the total number of about 8,200 species known to science only about 580 species and 40 species of fern allies are so far recorded from India. A census of these 580 species of ferns reveals that about 240 species are Himalayan, 190 South Indian and 150 Malayan. Thus from the analysis of the fern flora it is clear that the results fully tally with the analysis of Phanerogamic Dicotyledonous flora made by Chatterjee. Brühl's and Dixon's researches show that out of approximately 3,000 true mosses hitherto recorded from India about 32% are endemic to the Himalayas, 28% belong to Indo-Gangetic plains, Peninsular India, Ceylon and Malaya and about

40% are foreign immigrants. As regards the moss flora the endemic value is just lower than that of the Palaeoarctic element.

Mr. H. N. Dixon, the well-known bryologist, states that 'the summary of the publications on the moss flora of India gives results which no doubt confirm rather closely those derived from the study of higher plants. They show the following elements of the bryophytic flora probably roughly in a decreasing order of frequency, as follows:—

(1) Palaeoarctic element, including a considerable number of Arctic, Alpine, European, Asiatic, and North American species.
(2) Endemic.
(3) Indian Peninsula generally. The number of species common to the Himalayan range and the southern part of the Indian Continent is much smaller than either of the two previous categories.
(4) Burmese, Chinese, Malayan affinities. A considerable number, chiefly in the Eastern ranges, and especially marked in the Assam moss flora.
(5) Affinities with Western Asia, Caucasus, etc. A small number principally, as is natural, in the western part of the range, and particularly shown in the Hindu-Kush (*cf.* Herzog, 1938).

There are, of course, in addition to the above, smaller elements of cosmopolitan species, and a few others of a disjunct distribution. Of the latter, one of the most remarkable is *Aongstroemia julacea* (Hook.) Mitt., which was collected by Somervell on Mt. Everest at 19,800 ft. (6,000 m.), much the highest altitude of any moss so far recorded; a species only known elsewhere from the summit of Giant's Castle, Natal, and from one or two of the highest summits of the Andes. [For a wider study of this geographical distribution, Herzog's Geographie der Moose (Jena, 1926) may be consulted.]'

It is a well-known fact that an Alpine flora at a given level is richer in proportion to the height of the ground above it. Thus an Alpine flora of an altitude from 3,000–4,000 m. will be richer than the summit flora of a range of about that altitude.

Analysis of thallose and foliose liverworts discloses that 70 thallose and 108 foliose (total 178) species are hitherto reported to occur in India. Of the thallose, 50 are indigenous to India. Thus thallose liverworts represent 71·4% endemic to India particularly to the Himalayan region.

A census of fresh water and brackish water algal flora of India, which I have recently worked out, does not, however, lead to any definite conclusion with regard to the different elements in the algal flora of India. More intense systematic work on the algal flora requires to be done before anything with sufficient

accuracy can be stated. Careful examination of the habitats of the algae, so far recorded from India, indicates that there is a great predominance of the Malayan elements. My work on the marine algae from the coast of Bombay alone shows that the total number of species and varieties known to us from the western coast of India is 255, representing 5 species of Myxophyceae, 81 of Chlorophyceae, 38 of Phaeophyceae and 131 of Florideae. Endemic species, varieties and forms are only 45, thus representing only 17·6% of the algae recorded from this area of the seashore of Peninsular India.

South-Western Australia has many species common to the Malayan Archipelago. Hence from the point of view of algal distribution, the part of the water bordering the south-western coast of Australia may very well be considered botanically as a part of the Malayan Archipelago. The south-eastern element therefore becomes predominant in the algae of the western coasts of India as this element represents 50·2% of the Malayan and South-West Australian species, while the Atlantic or north-western element including Europe, Africa and the Mediterranean element is 42·7%. In this survey it has been revealed how a wrong statement made by Bφrgesen led to misleading speculation about the geographical distribution of the flora and fauna in this part of the Indian sea. Sewell states, 'It has recently been discovered that a very high percentage of species of marine algae are common to the Indian Ocean and the North Atlantic Ocean, some even occurring in the Arctic region.' This statement is evidently based on Bφrgesen's observation on the geographical distribution of the algae of the Northern Arabian Sea after Bφrgesen's comparison of Murray's sheets at Kew. 'It would be of great interest,' Bφrgesen remarked, 'to confirm the presence of the above-mentioned northern species found there by James A. Murray according to his collection in the Kew Herbarium.'

These remarks were, however, corrected by Bφrgesen himself in his subsequent examination of Murray's specimens when he asserts, 'But the most important result of the examination of the collection of the British Museum was to establish that none of the northern and arctic algae mentioned in my list were found in the collection. When I heard that the British Museum also possessed a large collection of J. A. Murray's algae from Karachi, I was, of course, especially interested in finding out whether the northern species were found there too. This not being the case, greatly increases my doubts as to whether they really live there, and seems to me to render it probable that they have come into Murray's collection found in the Kew Herbarium by mistake.' These later remarks of Bφrgesen, if consulted by Sewell, might have induced him to modify his hypothesis on the distribution of some of the marine fauna as well.

Thus Prof. Børgesen simply asserts that some of the specimens of Northern Arctic algae, referred to in his paper on the marine algae from the northern part of the Arabian Sea, found access into J. A. Murray's collection at the Kew Herbarium through a mistake. The northern specimens wrongly placed with the Murray's collection led Børgesen and Sewell to speculate on the migration of some of the northern temperate species in tropical seas and to draw certain rather far-fetched conclusions while dealing with the geographical distribution of the marine algae and animals on the northern part of the Arabian Sea. Some of Børgesen's arguments advanced to account for the occurrence of these northern specimens cannot be supported by previous data which established the dominating influence of Malayan and Australasian elements in the distribution of deep water and littoral algae in the tropical waters of the Indian Ocean. Børgesen's footnote, quoted above, to his paper on 'A list of marine algae from Bombay' where he points out his mistakes detected during his scrutiny of Murray's set of algae at the British Museum (Natural History), London, is of the greatest importance to phytogeographers and those interested in the distribution of seaweeds. Some of his views expressed under the heading 'Some Plant Geographical Considerations' demand further revision in the light of the distribution of species contained in the additional collection of James A. Murray's algae at the Calcutta Herbarium which he does not seem to have examined while dealing with the Bombay algae. The question of the distribution of marine algae is more complicated than that of the higher plants. The problem of distribution of marine algae is dependent on ecological factors, physical and chemical nature of the water, hydrographical and biological conditions in the Indian seas, geological history and periodicity and autecology of a sufficient number of species of algae representing the marine flora of the area traversed. Our knowledge of the Indian sea algae belonging to all the groups is far from complete, although some very valuable work by distinguished phycologists exists. It is, therefore, too early to draw any definite conclusion on the distribution of our marine flora.

As regards Charophytes, G. O. Allen recently disproved Alexander Braun's theory that 'the East Indian Characeae are far less peculiar than those of Australia, the greater part of them being found also in other parts of the world, although exhibiting different varieties'. About 55 species of Charophytic flora are known so far from India. Allen in his analysis definitely proved that about 30% Chara and Nitella are endemic to India proper. He further mentions that three species of *Tolypella* are recorded; also *Nitellopsis obtusa* and *Lychnothamnus barbatus* are among the recent records from India.

H. N. Ridley holds that 'if we examine the flora of India from the Himalayan region to Ceylon and Burma, we notice that it is composed of a series of elements common to other regions of the surrounding areas; of these we may eliminate for study purposes the weeds or plants intentionally or accidentally introduced by man and confine our attention to those which are indigenous, and we must make a distinction also between plants which have migrated overland and the seaborne or maritime species which have arrived by quite a different path. Hooker (*Flora Indica*, 1855) gave a division of the flora as then known into sections according to geographical affinity. More recent investigations have much modified his sections'.

'No story of plant distribution,' says Ridley, 'is complete without a considerable knowledge of tertiary palaeobotany nor can be understood without a comprehension of the position and form of land-surfaces during that period, the time of the evolution of flowering plants. The modern Asiatic flora is largely what remains of the Oligocene flora as represented in Europe and which probably occupied all tropical regions then above water. Many of the early genera and perhaps orders have disappeared owing to changes in land-surfaces and climate, but some species of that date seem to have persisted with little or no alternation to the present day. Further researches will enable us to correlate the extinct and living genera and probably to fix the date at which, and the locality where, they were evolved.'

It is therefore quite obvious from the different views regarding various elements of the living plants of India that Hooker's theory of endemisms in India needs revision. My rough analysis of the flora of India leads me to conclude that Hooker's views regarding different elements in the Indian flora demand considerable alteration in the light of recent systematic and taxonomical researches. There is very little doubt that India must have had her own flora, however large or small it might be, and that flora has been calculated by Chatterjee in the region of 70% of the total (approximately) 11,124 Dicotyledonous plants recorded so far from India. Mukherjee in his monograph on Labiatae has recorded 421 species and 69 genera. Of these, 261 are endemic and 85 species are confined to the Himalayas. Thus according to him too 62% of the *Labiatae* are endemic. Presence of sufficient endemicity has more or less been hinted by Ridley, Kashyap, Dixon and Allen. Chatterjee's estimate in all probability will be found to be true by the results of future workers on the different groups of Indian flora. Palaeobotanical evidence, as Ridley states, is expected to throw more light on this most important problem confronting the students of systematic botany interested in the Indian flora.

Scope of Systematic and Taxonomic Studies in India and Burma.

From the brief historical survey of the systematic and taxonomical studies of the Indian flora as sketched in the previous pages, it will be quite obvious that there lie enormous fields for researches on the Indian flora in the various classes of the plant kingdom. As regards Botanical Survey work proper, it consists more of outdoor or field investigations and less of work indoors. Briefly stated, field work covers the study of plants in nature throughout India and Burma, with the object, firstly of appraising the entire vegetable wealth of India, and secondly of increasing our knowledge of those plants, in all possible aspects, and finally making such knowledge available for the benefit, firstly of the people of the country, and secondly of the botanical world at large. It includes among others collection, classification, naming and preservation of plant specimens and plant products in a dry state in a herbarium and a museum to serve not only as standards for future reference but also as an assemblage of the entire vegetable resources of the land in one easily accessible central spot, and collecting of seeds and plants and acclimatizing living plants in a botanic garden for the purpose of their culture from which all minor establishments of the same nature should receive their supply. Medicine, Commerce, Agriculture, Horticulture and many valuable branches of manufacture derive much benefit from the Herbarium which forms the backbone of the Botanical Survey. Enlargement of the scope of systematic and taxonomical studies in India means, therefore, reviving the activities of the Botanical Survey by extending the ever-expanding Botanic Garden Herbarium which is, as rightly decided by the Indian botanists in the 1938 session of the Congress, the National Herbarium of India.

Ever since the organization of the Survey in 1890, its activities have been directed towards floristic work mainly, as the extent of unexplored regions was great, but now and then problems of economic importance have also been successfully tackled as a reference to previous reports of the Botanical Survey of India will disclose. But for some years past, the Survey has been passing through critical times, both in finances and man-power, which have conduced to the apparent inactivity in its own sphere of work.

A feature that keeps the Survey alive is the constant flow of specimens into the Herbarium sent by officers more fortunately placed than those of the Survey, who, in return for the present of specimens made by them, are supplied with lists of identifications and economic information. Apart from departmental work, the large volume of botanical investigation, covering a wide range of subjects, both in pure and applied botany, which has been done in the Indian universities, the Forest and the

Agricultural departments and elsewhere, shows a considerable advance in the proper appreciation of the value of the botanical work carried on by the officers of the Sibpur Herbarium.

The Botanical Survey, the oldest of the surveys, was recognized about fifty years ago at the instance of the late Sir W. T. Thiselton Dyer of Kew and Sir George King. The first volume of the Records of the Botanical Survey of India was published in 1893. Sir George realized the importance of the enormous vegetable wealth of this our vast sub-continent. The need for exploring the rich and varied floras growing on land and in the marine and fresh waters of India,—a flora several times richer than the continent of Europe,—was so greatly felt that Sir George undertook in right earnest the task of surveying the vegetable resources of the country on proper lines. In 1905 Sir J. D. Hooker, G.C.S.I., pressed for an organized effort towards botanical exploration of the unknown areas and emphasized the importance of preparing separate floras for the different provinces of India. Suggestions regarding botanical matters were also made by the Royal Society of London at about this time to the Under-Secretary of State for India. During the time of Sir David Prain, some enlargement of the Department was effected with the result that some of the important parts of the country were surveyed and valuable work of acclimatizing timber and fibre plants, oil-yielding plants, fodder plants and many other plants of great medicinal and economic value to the State were carried on at the Garden. During Lt.-Col. Gage's time, the Board of Scientific Advice, being impressed with the botanical work carried out at the Royal Botanic Garden, Calcutta, the headquarters of the Survey, proposed reorganization of the Botanical Survey of India in 1908. The proposals submitted by the Board were accepted by the Government of India but their implementing was postponed on account of financial stringency. The staff of the Botanical Survey of India was, however, strengthened to some extent in 1910. This staff carried on the routine work of the Department hitherto. There was a setback to the Department later on when sometime in 1927 the exploration grant was stopped and subsequently in 1930-31 one of the systematic assistants out of two of the Botanical Survey of India was retrenched. Since Mr. Calder's departure from India purely nominal routine work of the botanical aspect of the Survey has been kept going with the help of only one systematic assistant. The Botanical Survey of India has thus now been reduced to its present moribund condition. During the last 20 years when the sister surveys developed, the Botanical Survey of India which deals with the vegetable kingdom of the country spent a dormant period although the Royal Botanic Garden and the Botanical Survey Department form the backbone of the allied subjects, such as Forestry, Agriculture, Arboriculture,

Horticulture and Pharmacology which evolved from this Department. Similar botanical surveys even in such countries as South Africa, China, Philippines, Malaya and Java made rapid advancement in the meantime. During this period Japan, America, Germany and Russia ransacked the country and took away large collections of plants and seeds with a view to utilizing them for economic and scientific purposes. Unless the Botanical Survey of India is brought to its proper footing without delay and sufficient investigation be made of her unlimited vegetable treasures stored in our forests and the sea, India will lose a great market in the future. The strengthening of the Botanical Survey of India on proper scientific lines will undoubtedly result in, as Sir Arthur Hill on the eve of his departure from India in 1938 emphasized, 'great material benefit to India'.

The work of the Botanical Survey of India is based on the precious collection of the Herbarium materials at Sibpur and 15,000 living specimens cultivated in the Royal Botanic Garden, Calcutta. Such a collection is of the greatest value in dealing with such problems as naturalization of plants, the introduction of new vegetable products into the country, the adaptation of raw produce to the growing requirements of manufacturing industries, utilization of vegetable drugs, the management of the forests, the scientific improvement of agriculture, land utilization, irrigation and supply of good drinking water in the villages, the reconstruction of rural areas and the development and maintenance of Government gardens, parks and the scientific planting of useful plants and roadside trees. These aspects of systematic and taxonomic work of a botanical garden of the standard of the Royal Botanic Garden, Calcutta and Kew, were also stressed by Prof. E. J. Salisbury, F.R.S., in his presidential address at the 107th Annual Meeting of the British Association for the Advancement of Science in 1937. The progress in botanical science is therefore essential to a community in aiding the mother country in everything that is useful in the vegetable kingdom.

With the enlarging scope of the universities during the last few years there has been an appreciable advancement of our knowledge of the various aspects of the botanical studies. My experience of the work of the universities leads me to hold that the botanical departments of the universities, in addition to their teaching work, are well suited to carry on researches in anatomy, morphology, physiology, palaeobotany, cytology, embryology, microchemistry of plants and autecology or studying the life-history of plants and similar other branches of botany. The functions of the Botanical Survey of India, on the other hand, are confined to investigations on systematic or taxonomic researches on the different groups of the plant kingdom. Exploration of unknown and little known areas, botanical survey of the sweet and the marine and brackish water flora of the

Indian coast line, preparation of floras of both wild and cultivated plants on the results of explorations, monographic work, synecology of Indian vegetation in the different parts of the country, plant geography, plant acclimatization, study of economic and medicinal plants with special reference to their distribution and habitat—all come within the normal sphere of activities of the Sibpur Herbarium and the Botanical Survey of India at its headquarters in the Royal Botanic Garden, Calcutta.

Monographic work on important families and genera is also an important item of the work for the systematists of the Herbarium and the Survey. Such work is done by similar institutions in other leading countries of the world. These monographs form the basis of subsequent floristic works. The Annals of the Royal Botanic Garden, Calcutta and the Records of the Botanical Survey of India are meant for publishing exhaustive treatises embodying the results of the systematic and the taxonomic researches on the various groups of plants. The demand for comprehensive manuals of crops, drugs and various other useful plants, with necessary notes on their cultivation, horticultural and medicinal value and marketing facility is growing day by day with the rapid progress of botanical and agricultural sciences in India and abroad.

Our knowledge of the vast group of cryptogamic flora of the country has advanced very little during the last half a century. My census of Indian algae indicates that more than 75% of marine and freshwater algae are unknown to us. The algal flora are of considerable economic importance. Seaweeds rich in soda, potash, iodine and bromine are still the chief sources of iodine and many species are used as food, medicine, fertilizer, objects of art and fodder. *Chondrus crispus* is used in the manufacture of jellies and occasionally employed as a remedy in consumption. It is also given to cattle, after boiling, for rapid fattening. *Fucus vesiculosa* is given to pigs, hence sometimes called 'Swine-Tang'. It is used as fuel too. *Lamminaria saccharina* is eaten in Ireland and in Japan as a delicacy and is considered as 'poor man's weather guide', for a tuft suspended foretells rainfall by absorption of moisture. *Rhodymenia palmata*—'*dulse*' or '*duillisg*' chewed like tobacco or eaten as vegetable—and *L. digitata* are eaten in Scotland and cried about the streets in Edinburgh. *Ulva latisima* and *U. lactuca* (sea lettuce, oyster green) are edible and those who have acquired a taste for these relish them when served with lemon juice.

Gracilaria tenax, tough gum-weed, is used in China in the preparation of glue and varnish. All seaweeds are good manure and are utilized as such along the coastal regions. Species of *Gelidium*, *Gracilaria* and others found to grow along the Indian coasts are the well-known Ceylon-moss or Agar Agar used for food and culture medium for bacteria and fungi. Another sea-alga, *Porphyra vulgaris* which might be grown with success in

suitable portions of the coasts of Southern India, is cultivated for food in Japan by placing branches of trees in the mud of the sea. Japanese 'Liver', as it is called, is imported into England in dried sheets. The seaweed *Gloiopeltis* species is used by Japanese masons for making cement. The famous birds' nest of China (the sea-alga *Gelidium* sp., recorded also from the coasts of India) worth of £230–290 used to be exported from China some years ago. The various uses of seaweeds were summarized in the columns of scientific notes of the *Amrita Bazar Patrika* as follows: 'War has made seaweed—eaten in many forms in different parts of Britain—a familiar food to many people who had never heard of it as a food before. Dulse, a species of small, smooth-leaved seaweeds, is eaten uncooked by the Scots. In some parts of England it is served with roast mutton or as a savoury on toast. "Seaweed bread", sometimes called "laver bread", is popular on the Welsh coast.

'One American authority declared recently that the world is foolish to rely so much on wheat supplies, as there are equally good crops to be harvested from the sea. There was enough nutritious vegetation grown in the Sargasso Sea alone to feed all Europe, he said, if only it were harvested and prepared for human consumption.

'Seaweed is a valuable food, containing silica, lime, potash, nitrogen and carbon. There is seaweed to be had for the asking on any seashore. But take the seaweed that is washed up, don't tear it from rocks. It is important to remember that the growth of seaweed on rocks prevents coastal erosion.' This is indeed a valuable note based on scientific facts.

Fossil beds of Diatoms or Diatomaceous earth may be discovered in the neighbourhood of the Andaman and Nicobar Islands. Diatomaceous earth is of great importance as a commercial product. Researches reveal its varied uses for industrial purposes. It is used 'as an absorbent for liquid nitroglycerine, to make an explosive, dynamite, that could be transported with comparative safety', and in the 'filtration of liquids, especially those of sugar refineries'. It is a very efficient insulator for a temperature over 1000°F. and is also used 'as the base of polishes for cleaning automobiles finished in artificial lacquers'.

Other industrial uses of the seaweeds, such as for sound deadening, heat and cold insulation, etc., are of increasing importance in trade. The marine and freshwater plankton algae are the chief food for fishes and are therefore of the greatest value to pisciculture. The great importance of algae in relation to fisheries has been proved by the recent investigation carried out in the Marine Biological Station at Plymouth and the Freshwater Station of Windermere, England, where algae in relation to fishes and freshwater supply are studied. My own investigation too fully establishes the importance of algae in

pisciculture and supply of oxygen to the water. Polunin rightly insists on the war-time use of plankton as there is sufficient possibility of 'obtaining food direct from the marine plankton'. 'It is well known that many macroscopic animals, such as fishes and seals which are important for man's food and fuel, are to a very large extent dependent upon plankton ultimately and indirectly phytoplankton for their own food.' A thick coarse species of Spirogyra are widely eaten in the Northern Shan States in Burma. They are dried in bundles, packed in boxes, and sold in the market. My researches reveal that green and blue algae and Diatoms play an active part in the purification of water, irrigation and drainage. The filamentous forms with other aquatic plants often provide obstacles for effective operation of irrigation systems and lead to various biological problems affecting health and communications of people. The rôle of algae in the filter works of Calcutta and other cities has been clearly established in my papers on the algae of the filterbeds. The relation of algae and mosquito larvae is also an important problem in malariology in our country. In the Chilka Lake the vast spreading sheets of algae composed of *Lyngbya aestuarii*, *Cladophora crispata*, *C. calicoma* on the flat muddy foreshore and the floating trichoplankton consisting of *Potamageton pectinatus* interwoven with threads of *L. aestuarii* provide ideal condition for food and shelter of the malaria-carrying mosquito larvae.

Examination of the gut contents of mosquito larvae reveals that a good number of blue-green and green unicellular and colonial algae form food of the larvae. The larger filamentous algae serve as ideal shelter and foraging ground for them and hence these larvae flourish in such favourable conditions in the stagnant khals, canals, creeks, tanks and jheels. The importance of the soil algae, particularly blue-green algae on or near the surface for fixing nitrogen and the presence of other algae aiding in nitrogen-fixation by bacteria and thereby increasing fertility of our cultivated lands, particularly rice-fields, is gradually gaining more and more ground. Limnological investigation, which is of such great importance in these days, is based on the systematic determination and analysis mainly of the algal flora. The uses and various other aspects of the study of algae have already been dealt with by Prof. M. O. P. Iyengar and Dr. S. L. Ghosh. The subject was discussed at some length at the Silver Jubilee Session of the Indian Science Congress Association held in Calcutta. I need not therefore give further details here.

The recorded Fungi of India was estimated by the Sub-Committee of the Board of Scientific Advice in 1907 at 1,700 species. This is according to E. J. Butler, who was appointed first as a cryptogamic botanist at the Royal Botanic Garden, Calcutta, to work on algae and was subsequently appointed as

plant pathologist of the Agricultural Department in 1901. He considered this estimate of the fungi known then from India is only one-fifth or one-seventh of the number of species actually existing in the country. It was also stressed at that time that the algae are practically unstudied. The mosses and ferns are, with the exception of a few smaller groups, fairly well known. Of these four main sections of the cryptogams, the fungi are both numerically and from their practical interest to man the most important. But if we take our ignorance of any particular section as the measure of the need for its study, then the algae are the groups most requiring investigation.

Some valuable work on fungi causing diseases to crops and timber has been done by Butler and others and are being carried out on proper lines by Bose at the Carmichael Medical College, Calcutta, Padwick at the Imperial Agricultural Research Institute, New Delhi, Mehta at the Agra College, Chaudhuri at the Panjab University, Das Gupta at the Lucknow University and Bagchee at the Imperial Forest Research Institute, Dehra Dun. But our knowledge of non-parasitic fungi is still very deficient. Any of the harmless species of fungi may turn out, at a particular stage of its life-history and under favourable conditions, to be a virulent disease of economic plants. About 200 species of fungi have been found to be edible ones. The records of all these and more are essential to the benefit of the country. Systematic work on non-parasitic and parasitic fungi and algae, and preservation at the same time in a central herbarium of types and co-types of the new species recently discovered, is of the greatest importance.

Mosses and liverworts are groups of lower plants whose study is important from the standpoint of evolution of plant kingdom. Apart from its pure scientific and educative value they are by no means less important in the prevention of sheet erosion, preservation of plant food in the soil and colonization of higher plants. Some of the mosses are used for decorative, packing and other useful purposes too. I received some time ago several enquiries from abroad for the supply in large quantity of coloured mosses for decorative purpose. There is, therefore, some commercial value of mosses as well.

Among the non-flowering plants, ferns and fern allies of India have received much more attention than the other groups. My recent work on the fern and fern allies reveals, however, that the earlier works badly need revision in the light of recent information. These plants are not only of considerable importance in biological researches, but some of them (some fern sp.) are used as vegetable and are mixed with flour paste for the culture of yeast which is subsequently utilized as an ingredient for the manufacture of country liquor or Indian beer (Haria), a favourite drink of the labourers in the hills and nearly all

over India. Some species of Lycopodium and fern are also of great medicinal value.

Ecology is a subject of far-reaching importance and application in the agronomy of India. It goes hand-in-hand with that of floristic survey and each is so inextricably mixed up with the other that to separate one from the other would resemble the separation of the salt from the sauce. Salisbury rightly emphasizes while dealing with the 'Ecological Aspects of Plant Taxonomy' that 'any such study presupposes an exact knowledge of the precise nature of the systematic aggregates that are involved, otherwise there is inevitable obscurity and confusion of issues. The ecologist is thus dependent upon the taxonomist for the discrimination, from the morphological point of view of the material with which he deals'.

Ecological work based on systematic and taxonomical studies has a very direct bearing on many problems of practical importance, while the usefulness of plant acclimatization investigations in the introduction of economic or ornamental plants from other countries into India is self-evident. Ecological investigation is very helpful in forestry for the preparation of working plans, silvicultural operations and other items of forestry. It is also of considerable importance in dealing with the question of preservation of fertility and moisture in the soil, for preventing soil erosion and reducing intensity of light and other factors conducive towards the betterment of cinchona, tea and coffee plantations. 'All our ecological problems,' remarked Dr. Bor in the concluding paragraphs of his address last year, 'can be correlated with the different meanings and implications of the word "conservation". Any activity of man which deals with the conservation of soil, of vegetation, of water supplies, etc., must imply a thorough understanding of the fundamentals of the theory of vegetation and ecology.

'Take the following fields of human activity and endeavour: forestry, agriculture, grazing, land classification and planning, management of wild life, anthropology and many others of like nature, in which the reactions and coactions of living things upon one another lead to certain states and raise certain problems —I submit to you that the only logical approach to those problems is the dynamic one of modern ecology.'

Standard of Work in Systematic Botany.

The standard of botanical research work in India should be of the same high order as that of the other advanced countries of the world. In the investigation of lower plants India is still behind not only of Japan but also of some other backward countries. It has been noticed that there is a tendency towards compilation work on a large scale. Economic and medicinal

plants, most of which are already described and figured in more than one well-known book and whose uses in many cases are exhaustively and properly recorded, are again treated in a slightly different form. For example, the plants dealt with in the Watt's Dictionary of Economic Products of India have been published with some modifications in several subsequent voluminous works. Pictures contained in such recent works are copied, at a considerable cost, from well-known Icones and plates such as Roxburgh's Icones, Botanical Magazine, Wallich's Plantae Asiaticae Rariores and similar other standard old publications preserved at the library of the Calcutta Herbarium.

I admit that there is some importance in compilation work but when such work is done at a high cost with very little additions and alterations, the prices of the new publications become too high and thereby debar many interested persons from purchasing such books. They are thus equally inaccessible to the public as the previous publications.

The need for original work on modern lines is nowadays growing. Fresh avenues of vegetable products of economically and medicinally useful, unknown and little known plants, both indigenous and introduced, should be explored. The active principles and healing properties of these plants at various stages of their life-history and at different ecological conditions should be studied by the university workers in collaboration with the systematists who are to identify and describe and work out their range of distribution in different parts of India and adjacent countries. After such investigations when the economic and medicinal importance of a species of plant is definitely established, it should then be cultivated on a commercial scale in suitable localities. If even one dozen plants are thus worked out in a year, this may then be considered as substantial progress for the benefit of mankind.

Proper systematic and taxonomical work has both on the purely scientific and on the economic sides an educative function which, by its nature, is beyond the scope of any department or any university other than the Royal Botanic Garden, the Botanical Survey of India and the Forest Research Institute, Dehra Dun. This function entails the upkeep and continuous development of a public herbarium and a museum to illustrate in readily intelligible form the outlines of botanical science in general, and the vegetation of the Indian Empire and its chief economic vegetable products in particular. It will thus be obvious why the magnitude of the scientific work which comes within the purview of the Botanical Survey of India prompted the experts some time ago to suggest 10 Botanists, 5 Chief Botanists and 12 Agricultural Botanists in addition to the Director and Deputy Director of the Botanical Survey of India and Curator of the Herbarium for discharging efficiently all the functions of the Botanical Survey of India.

The time has long gone by when a progressive country can afford to be satisfied with a knowledge only of the larger plants of its vegetation. Not only are the primitive forms of plant life equally important to the plant geographer and the general botanist, but they have a practical significance which makes it impossible to ignore them. All the arguments, scientific as well as economic, in favour of having a survey of the higher forms of plant life (such as the Indian Botanical Departments have hitherto mainly concerned themselves with) apply equally to the lower.

It has rightly been stressed by such well-known scientists as Lt.-Col. A. T. Gage, I.M.S., the then Director, Botanical Survey of India, G. A. D. Stuart, I.C.S., Officiating Agricultural Adviser to the Government of India, P. H. Clutterbuck, Esq., C.I.E., V.D., F.Z.S., F.R.G.S., F.E.S., Officiating Inspector-General of Forests, E. J. (now Sir Elwin) Butler, Esq., M.B., C.M., F.L.S., Joint-Director, Imperial Agricultural Research Institute, and Lt.-Col. H. Ross, O.B.E., I.M.S., Assistant Director-General, Indian Medical Service, that 'recent events have proved beyond all doubt that expenditure on scientific research is one of the most profitable investments a Government could take up. It has been made abundantly evident that the country that neglects the scientific investigation of its natural resources pays very heavily in the long run for its neglect'. This is a hundred times true in these days of scientific progress. The future agricultural and industrial developments of India demand that the inexhaustible vegetable wealth of her forests, freshwater areas and vast coast line should be properly worked out for the welfare of the people of our country.

Modern Trends of Systematic and Taxonomical Studies.

Systematic and taxonomical studies of plants received the attention of the Hindus more than 2,500 years ago. Plants were studied in ancient times mainly from two aspects—philosophical and utilitarian. Plants were used by the ancient *Rishis* and sages in India from the Vedic period in connection with their performances of various rituals. In the Vrikha-ayurveda plants were dealt with in relation to agriculture, horticulture and arboriculture. Medicinal plants received the particular attention of the two ancient authors of Ayurveda, namely, Charaka and Susruta. It is not unlikely that the knowledge of plants, either from philosophical or utilitarian point of view, spread gradually from Hindusthan to Europe through Arabia, Syria and Greece. It was further advanced when Alexander the Great visited India. Over 1,500 years ago Aristotle and Plato, like our sages of the past, held 'the recognized and vital principle of plants'. According to Aristotle, 'the soul of the plant was nutritive only, and

thus on a lower plane than the soul of movement and feeling in animals and the reasoning soul in man'. Botanical knowledge in Europe advanced from its inception through the herbalists and gradually developed from such works as the *Enclyclopaedia of Bartholomaeus* and the *Book of Nature*. Subsequently along with the botanical renaissance of the sixteenth and seventeenth centuries, botanical science was established in Europe on proper lines. There was at this time a gradual evolution of the classification of plants. Such a classification was more or less of the same type of grouping of plants according to their habits as was followed by the ancient Hindus. Cesalpino classified plants as trees, shrubs, undershrubs and so on, whereas d'Alechamps in his *Historia plantarum Lugdunensis* recgonized 18 classes of plants according to the medical properties and morphological and ecological nature of the plants known to him at that time.

After this period, systematic and taxonomical studies on classification of plants took its proper form in the hands of Linnaeus and de Candolle and reached its present highly advanced form by researches of Bentham, Hooker, Engler, Rendle and Hutchinson and many other modern monographers. In olden days plants used to be described by a few words only. These words signified the most important distinguishing specific characters alone. With the development of science it was thought that such a description was inadequate and description of plants should be more exhaustive so that the set of permanent characters of family, genus and species and also of the allied species were all co-ordinated. There was thus a gradual transition from the artificial to the more elaborate natural system of the present day and the naming of plants was thoroughly systematized by the international rules of botanical nomenclature.

It is still a disputed question as to what should be the perfect system of classification and the best method of describing a plant. Recent investigations on the various aspects of botanical science throw considerable light towards clarifying and stabilizing the status of a genus or a species. The labours of the university workers devoting their energy to investigations on morphology, ecology, anatomy, genetics, plant-breeding, embryology and cytology apart from systematics and taxonomy, are fully rewarded in the correct stabilization of the systematic position of a genus or a species of plant. With a view to discussing what should be the perfect system by which a plant can be described with the full co-ordination of the vast data at present available from the workers on different aspects of botanical science, an 'Association for the study of systematics in relation to general biology' was formed in London in 1938, of which I as a member from India had the opportunity to be present at the inaugural meeting and took part in the discussion. 'The result,' as stressed by Julian Huxley, 'has been that the

outlook for taxonomy has altogether changed. Even a quarter of a century ago it was possible to think of systematics as a specialized, rather narrow branch of biology, on the whole empirical and lacking in unifying principles, indispensable as a basis for all biological workers, but without much general interest or application to other branches of their science. To-day, on the other hand, systematics has become one of the focal points of biology. Here we can check our theories concerning selection and gene-spread against concrete instances, find material for innumerable experiments, build up new inductions: the world is our laboratory, evolution itself our guinea-pig.'

It is generally agreed by modern botanists that all the data obtained from the various field, experimental and laboratory work should be considered in order to reach sound taxonomic, phytogenetic or phytogeographical knowledge by a synthesis of methods. Thus 'Marsden-Jones and Turrill for the bladder-campions (*Silene*) have worked on the following principles: (1) a systematic investigation of material accumulated in herbaria and museums, correlating this with a critical reading of all published literature relevant to the subject; (2) a field investigation, by both phytogeographical and ecological methods, of the distribution of the species concerned in all their varieties and forms; (3) controlled selfing and crossing and growing in experimental grounds; (4) growing genetically investigated material under different environmental conditions in order to study the modifying effects of external factors; (5) cytological investigation of wild and cultivated material; (6) anatomical studies of vegetative and reproductive organs; (7) study of fossil material, so far as available.'

'It is only by a combination of all methods, herbarium or museum, library, laboratory, field and breeding, that there is any hope of obtaining satisfactory evidence on the nature and genesis of taxonomic units. No method is sufficient by itself, yet each is essential. As an important part of the synthetic method, experimental taxonomy will take its place in the scheme of 'The New Systematics'.'

Conclusion.

Modern works on systematics and taxonomy lead to certain general principles which should be followed in tackling a species or groups of species based on evolutionary progression. A taxonomist should pay special attention to constant characters and tendencies, different categories of the characters and their relative values and different stages of evolutionary progression. Systematics and Taxonomy will profit by practical methods and examples with special reference to angiosperms as suggested by Sprague. Particular attention should be paid to the International Rules of Botanical Nomenclature. Strict adherence

to the rules is imperative in describing a new species, varieties or forms or making new combinations.

Systematics and taxonomy form the basis of botanical researches. The scope and value of systematic and taxonomical work was strongly advocated by the Russian worker Vavilov in his following observations :—

'Systematics, in our understanding, is the basis of knowledge of the plant and animal kingdom. It was not by mere chance that the greatest evolutionist, Charles Darwin, started his work from systematics.

'Some biologists are of the opinion that the age of classical systematics is at an end. From our personal experience we have come to the conclusion that even for cultivated plants, such as wheat, potatoes and fruits, this is not quite so. For there are vast areas in South America, Central America, and southern Asia with enormously rich floras, which have not yet been studied even superficially. If we say this from our experience with cultivated plants, it is still more applicable to wild floras. Thousands and thousands of new species are yet to be discovered. And the lack of even such superficial knowledge is a great hindrance to our general understanding of the flora and fauna of the world. The basic biological work, which must embrace a knowledge of the entire flora and fauna of the world, is not yet finished, even in its first approach, *i.e.* in the Linnean understanding of species. But from what we have already said here it is sufficiently clear that we regard classical systematics, which works only with Linnean species, as merely a first step in biological knowledge and quite superficial for the purposes of practical plant and animal breeding. Nor does it satisfy requirements of a thorough study of species from an evolutionary point of view.'

'We are now entering an epoch of differential, ecological, physiological, and genetic classification. It is an immense work. The ocean of knowledge is practically untouched by biologists. It requires the joint labours of many different specialists—physiologists, cytologists, geneticists, systematists and biochemists. It requires the international world. The most remarkable regions of the world, the cradles of primitive civilizations—the mountainous regions of southern Asia, Central and South America—are still in need of investigation even as to their resources of cultivated plants and domestic animals.'

'We do not doubt that the new systematics will bring us to a new and better understanding of evolution, to a great increase in the possibilities of governing the processes of evolution, and to great improvement in our cultivated plants and domestic breeds of animals. It will bring us logically to the next step: integration and synthesis.'

It is, therefore, imperative that more attention should be given to the systematic and taxonomic studies in our universities

so that some of the enthusiastic workers of the younger generation of botanists may equip themselves with the latest methods of systematic and taxonomic researches and thereby explore the vast vegetable resources of our country. The scope for the systematic researches in India is enormous both in the theoretical and the applied aspects. With the discovery, as a result of systematic researches, of the unknown and little known plants of commercial, medicinal, agricultural and horticultural importance, systematic botanists of future India will contribute their share towards agricultural and industrial developments of their mother-land when she emerges, with her spiritual armour, from the present ordeal as the free Hindusthan. The Indian botanists must play their part in shaping the new world order along with the other scientists, as members of a free Indian nation, taking their legitimate position among the federation of the free nations of the world, which, after the present devastating war, I am sure, will be readjusted on a basis of justice, equity and fairplay.

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SECTION OF ZOOLOGY AND ENTOMOLOGY

President :—B. CHOPRA, D.SC., F.N.I.

Presidential Address

(Delivered on Jan. 3, 1943)

PRAWN FISHERIES OF INDIA

I deeply appreciate the honour that the authorities of the Indian Science Congress Association have done me in nominating me to preside at the section of Zoology and Entomology this year. As the new name of our section shows, the entomologists, who had strayed from the fold three years ago, are happily back with us again, and in extending them a hearty welcome, I am sure, I voice the feelings of all of us.

Provision of food has always been a major problem with man and has acquired a very special importance in these days of international strife and struggle. The 'Grow more Food' campaign that is being vigorously pursued all over the country is certainly a step in the right direction, and, in spite of the acute shortage that is temporarily being felt in many provinces, it is pleasing to read in the papers that hundreds of thousands of additional acres are being brought under cultivation of wheat, rice and other food crops, and attempts are even being made to replace the grass lawns and flower beds decorating the compounds of offices, colleges and schools and Government residential buildings with fields and plots for growing vegetables. This is all to the good, but simultaneously with these, our efforts should also be directed towards increasing the supply of our fishes and various animal husbandry products. Except for a somewhat feeble attempt by one of the Provincial Governments to start a campaign of 'Grow more Fish', I have seen no evidence that this aspect of the food problem is being given as much attention as it deserves. Fish, to use the term in a broad sense so as to include in it prawns, crabs and other shell fishes, is a very important article of diet over large parts of India and any efforts that are made to make available to the people large supplies of fish in a wholesome condition and at cheap prices will materially help in solving the food problem. Considerations like these have induced me to present some aspects of the Prawn Fisheries of India as the subject of my address.

Next to agriculture and perhaps animal husbandry, fishery is the biggest industry of our country. It provides employment and means of sustenance to lakhs of people all over India and its total annual yield must run into enormous figures. Prawns and crabs form a very important part of our fisheries, and in some markets are of greater importance than any kind of fish. I once estimated very roughly that the prawn fisheries of India must be worth at least 3 crores of rupees every year, but I feel that this figure was far too conservative.

Our primary concern as Zoologists is with the animals on which these fisheries depend and I shall, therefore, first give a brief and general account of the different species of prawns, shrimps and lobsters that are of commercial or semi-commercial importance in the country.

All prawns and shrimps—I use the words 'prawns' and 'shrimps' in the generally accepted sense, that is, that the larger forms are prawns and the smaller ones are shrimps—are aquatic and the more important of our commercial species live in the sea, backwaters, lagoons and in the estuaries of our great rivers. First in importance are the Penaeids, known in trade circles in many parts of India as the 'sea prawns'. The Penaeidae are easily distinguishable from the freshwater prawns and shrimps of the family Palaemonidae by the fact that the first three legs are chelate; in the Palaemons only the first two end in claws. *Penaeus carinatus* Dana is the largest of our Penaeids and is fished on a large scale in all maritime provinces of India. It usually grows to a size of 7″–10″, though it may sometimes attain a length of well over a foot. Along the Sind and Bombay coasts, in the backwaters of Malabar and all along the Eastern coast of India this species is of great commercial importance. Like many other Penaeids, it is a migratory species, ascending the estuaries and entering backwaters and, in general, making its way into water of low salinity only at those seasons in which it is not breeding. Though the life-history of any Indian Penaeid is not fully known, it seems fairly certain that *P. carinatus* migrates into the sea at breeding time. It is quite abundant in the Chilka lake in Orissa practically throughout the year, even at times when the water is quite fresh, but no early post-larval stages seem to occur in the lake. Similarly along the Malabar coast the species is fished commercially in the backwaters from January to April, but from May onwards it is scarce in these waters but is found in great abundance in the adjoining littoral areas. The largest females collected in the backwaters seldom possess mature gonads, while those of 6″ and over from the sea have ripe ovaries.

Penaeus indicus M.-Edw. is perhaps next in commercial importance and certainly so in point of size. It generally attains a length of 6″–8″. In the Chilka lake and parts of the Madras Presidency and along the Sind coast it is perhaps of

greater commercial importance than *P. carinatus* even. In the Chilka lake it is found all the year round and thus is able to live for a considerable time in water that is quite fresh. In habits, etc. it closely resembles the preceding species.

Two other Penaeids of great importance in Bengal, and along the Bombay and Sind coasts, are *Metapenaeus brevicornis* (M.-Edw.) and *Metapenaeus monoceros* (Fabr.). *M. brevicornis* is one of the commonest Penaeids of Bengal, where in the flooded low-lying areas it is found in paddy fields in very large numbers during and after the rains. This has given the species the local name of 'Dhanbone chingri'. *M. monoceros* is of great commercial value in Bengal, the Chilka lake, Madras, Travancore, Bombay and Sind. This Penaeid is a very hardy creature and living individuals are often available in the Calcutta markets. In some parts of Bengal it is known as 'Honye chingri' or the mad prawn, from the fact that even long after capture it keeps jumping about like a supposed mad person. Two other species of the genus *Metapenaeus*, *M. affinis* (M.-Edw.) and *M. dobsoni* (Miers), are of great value in Travancore. These are very abundant in the backwater lakes during the prawn-fishing season and constitute the bulk of the commercial sea prawns. *M. affinis* is common in the sea from May to October and in the backwaters from January to May. Specimens caught in the sea in July and August have mature gonads. *M. dobsoni*[1], on the other hand, is only scarcely found in the littoral regions, but is extremely abundant in the lakes. Large specimens are under 3" in length, and maturity is attained when the males and females are about 2" and 2½" long respectively. Though in this form also breeding probably takes place in the sea, there is some evidence that suggests that, unlike most Penaeids, *M. dobsoni* breeds at least partly in the lakes. This prawn is 'cultured' on a large scale in Travancore; I deal with this aspect in a subsequent part of my address.

Though there are many more Penaeids that are of commercial importance, it is necessary to mention only the common Travancore species, *Parapenaeopsis stylifera* (M.-Edw.), which grows to about 4½" in length and is fished on a very large scale in the littoral regions there. The species has a long breeding season; females breed a number of times in successive years before attaining the maximum size. In a majority of specimens of over 3 inches caught from June to October the gonads are found to be mature. This prawn has not been obtained from the lakes, and there is evidence that the species is not migratory.

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[1] According to a yet unpublished paper on the Prawns of Travancore by Mr. S. Natarajan, which I have had the privilege of seeing, this represents an undescribed variety of *M. dobsoni*. In dealing with the bionomics, etc. of some of the Travancore species, the valuable information collected by Mr. Natarajan has been of great help to me and I thank him sincerely for allowing me to make use of his unpublished paper.

I shall now mention a few freshwater prawns that are commercially fished in our country. These for the most part belong to the family Palaemonidae. Like the Penaeids which, though marine, are able to live in fresh or almost fresh waters, the members of the essentially freshwater family Palaemonidae have adapted themselves to brackish water conditions and can even tolerate sea water for considerable periods. Another feature worth mentioning is that many Palaemonids, like the Penaeids in general, migrate between fresh water and brackish water at different stages of their life-histories.

The most important commercial freshwater prawn is *Palaemon carcinus* Fabr. This is a large animal reaching to over a foot in length, the large chelipeds of the male adding another 17 or 18 inches to its size, and a single specimen may weigh well over a pound. The species is very common in the lower reaches of rivers, lakes, *bheels* and tanks in Bengal, Madras, Bombay, Sind and several other parts of the country. In the low-lying parts of Travancore, as also in the backwater lakes, at times when the salinity is not high, the species is found in great abundance and during September to November it forms the bulk of the freshwater prawns sold in some of the markets. In Travancore mature specimens of *P. carcinus*, including egg-bearing females, are commonly seen in freshwater areas in September, but in October and November, while salinity is still low, they migrate into brackish water lakes. Hatching and completion of the early stages of development appear to take place in the lakes. During this period the species is more or less absent from fresh waters, but by June very young individuals start appearing in the canals and rivers and a month or two later still larger forms are quite abundant. Though the full life-history is not known, it appears fairly certain that ovigerous females migrate into brackish waters for breeding, that early development takes place there and that the young ones migrate again into fresh water where maturity is attained.

Another freshwater prawn of considerable importance, in Bengal and Orissa at least, is *Palaemon rudis* Heller. This is common in Bengal from August to October, when large numbers of egg-bearing females are brought to the markets. In the Chilka lake this is the commonest Palaemon fished in large quantities from September to November. Large males and egg-bearing females are common in the lake in September and November, when the water is fresh or only slightly brackish. At other times of the year the adults are not seen, but young individuals are frequently met with in February and March, when the water is of moderate and sometimes of quite high salinity. According to Kemp, prawns of this species while still young migrate into the flooded rice fields and other bodies of water during the monsoon, when access to these areas is easy. In the freshwater season of probably the following year when

the eggs of the females are ripe, both males and females return to the lake. Early development takes place in the lake. Another species larger in size than *P. rudis* and quite abundant in the Chilka lake and many parts of Peninsular India is *P. malcolmsonii* M.-Edw. Like *P. rudis*, this species also visits the Chilka lake for breeding, but as the males do not appear to accompany the females impregnation of the ova must be taking place outside the lake.

Palaemon idae Heller is a species of considerable economic importance in South India and especially in Travancore. The males grow to about 4½″ in size, the females being an inch or so smaller. The species is fished extensively in the backwaters of Travancore from September to December. It can tolerate waters of high salinity and has even been collected in the sea round Java. Under favourable conditions *P. idae*, like several other Palaemons, migrates between fresh and brackish waters. Its breeding season appears to be a long one, lasting from September to almost the end of February, and females, which become ovigerous at a size of 2″, probably spawn a number of times before attaining their maximum size of 3½″.

I shall now mention a few of the smaller forms of commercial importance, many of which make up for the smallness of their size by the vast numbers in which they are caught. *Leander styliferus* M.-Edw. belongs to the family in which Palaemons are included. This along with an allied species, *L. tenuipes* Henderson, is extremely common in the Gangetic delta and vast quantities are sold in the markets mostly frequented by the poorer sections of the population. These two species, according to Kemp, 'are apparently seasonal immigrants to brackish water, ascending estuaries and tidal rivers, possibly for breeding purposes, when the monsoon floods are abating'. *L. styliferus* is of very great commercial importance in Bombay also.

Members of the genus *Acetes*, of the family Sergestidae, are mostly small in size, rarely exceeding an inch in length; they occur in vast shoals, swimming in mid water or near the surface. They are common near the shore and frequent the estuaries and backwaters. Although they are sometimes found in places where the water is even quite fresh, they very rarely penetrate beyond the reach of tidal influence. Some species are fished commercially in different parts of India. Of these *A. indicus* M.-Edw. is perhaps the largest in size, full-grown females measuring over an inch and a half in length. *A. serrulatus* (Krôyer) and *A. erythraeus* Nobili are also of commercial importance, especially in Madras and Travancore. As already remarked, species of *Acetes*, especially during their breeding season, appear in large shoals in coastal waters, drifting with the currents. At such times, besides providing an important fishery, they are ravenously fed upon by a large number of our edible shoal fishes. The vast quantities in which these little shrimps are

consumed may be judged by the fact that in the Paris Museum there are said to be some specimens of *Acetes indicus* bearing a note that these were taken from a large fish, the stomach of which was filled with myriads of these little crustaceans, which were carried away in bucketfuls by the fishermen. In addition to *Acetes* there are several other shrimps that we eat indirectly in so far as they form the food of our edible fishes. The pink or red colour of the salmon is believed to be due entirely to the shrimps on which it feeds while it is in the sea and in the case of the Bombay Duck—*Harpodon nehereus* (Ham.), a valuable food fish of our country—the migration of the fish can generally be traced by the movements of shoals of shrimps on which it feeds during certain seasons.

No true lobsters are found in Indian waters, but there are two species of spiny lobsters or sea crawfish that are of commercial importance. *Panulirus polyphagus* (Herbst) grows to about 15″ in size, but large examples rarely weigh more than 2 pounds. It occurs commonly in several localities along both the coasts of India, though it is commoner along the East coast and prefers a rocky or stony bottom beyond the low-tide limit. The commoner species of the Bombay coast is *Panulirus ornatus* (Fabr.). This is comparatively a smaller and lighter creature and is found in large numbers on rocky beds. It generally lives in water shallower than that in which *P. polyphagus* lives, though both the species are found in deep water also. Along the Bombay and Sind coasts egg-laden females are generally taken from November to January. In India spiny lobsters are not commercially as important as the true lobsters are in Europe and America or even as the spiny lobster is in South Africa. In size and weight also they are much smaller than the European and American lobsters. In Europe and America there are authentic records of lobsters varying in weight from 14 to 23 lb. each. Even these records pale into insignificance when compared with that of the ancient writer Olaus Magnus, who in an 'unnatural history' story states that between the Orkneys and the Hebrides, to the west of Scotland, there lives a kind of lobster so large and so strong that it can catch a swimmer in its claws and squeeze him to death. He even gives a picture of this mighty lobster showing a bearded man held as a mere plaything in the arms of this giant crustacean. I do not know whether to be thankful or sorry for the absence of such lobsters in our waters, for, though a menace to some unwary swimmers, they would have helped us in our 'Grow more Fish' campaign.

Though practically all prawns are edible, I believe I have dealt with such of the species as are of any great commercial importance in our waters. I shall now describe very briefly their fisheries in a few important and selected areas. As has already been stated, several species of great economic importance occur abundantly in the Gangetic delta in Bengal, where in the

brackishwater creeks in the Sunderbans and along the foreshore conditions are extremely favourable for their growth and propagation. There are large-scale fisheries for these animals in several districts and especially in Khulna and Bakarganj. Large and medium sized Penaeids, like *Penaeus carinatus*, *Penaeus indicus* and *Metapenaeus monoceros*, are the mainstay of these fisheries, but smaller forms like *Leander*, *Acetes* and *Caridina* are also fished and even the lowly *Mysis* is not spared.

The fisheries here, as everywhere else, are primarily for fish, but prawns and shrimps form a very appreciable portion of the catch, both in quantity and value. Similarly, though prawns are caught in small or large numbers in most of the different kinds of nets used by the fishermen, there are some nets that are especially used for prawn fishing more commonly than others. *Behundi* or *Behuti* or *Bada jal* is the most important net in this respect. This is a fixed purse net, with a wide mouth, short wings, fairly long cod end open terminally, the open end, however, being tied with a string when the net is in operation. Near the cod end there is invariably a flap or a small inner open bag so that prawns, etc. entering the net find it difficult to escape. This net is designed to operate in localities subject to strong tidal action and the size of the net and of the mesh varies with the strength of the tides, so that higher up in the estuaries, where tides are naturally weak, smaller nets with a closer mesh are used. A larger *Behundi jal*, like those operated by the Chittagong fishermen at the Dubla Island, may measure 120 feet from wing to wing with a bag of about 75 feet from the mouth to the cod end, while the smallest type used at Port Canning on the bank of the Matla river is only about 15 feet long. The mouth of the bag is set against the current and the water passing through it brings in large quantities of fish and prawns. When the tide turns the nets are either removed or reset with the mouth facing the current. In smaller rivers and creeks these nets are used singly, but in deeper and larger rivers and estuaries and on the foreshore they are set in a series of, sometimes, as many as seven in a line along a steel cable attached to floats. Another net commonly used in shallow waters is a sort of trawl net, known as *Moi jal*. The mesh is usually small, sometimes as small as 1 cm. in the lower portions and an inch or less towards the top. It is a rectangular bag with the lower margin threaded on a series of small iron beads. The net is dragged on the bottom so that the beads disturb prawns and tiny fish, which are caught in the bag.

Vast quantities of prawns and shrimps are caught in several areas all over the Gangetic delta. The catch is consumed fresh by the local inhabitants or is sent to the neighbouring markets, even some distance inland, and the surplus, which is sometimes very considerable, is dried chiefly for export purposes. In

several districts in Bengal, notably in Khulna and Bakarganj, there is a flourishing industry in dry prawns.

Prawns are sun-dried or smoked or boiled and sun-dried. I shall briefly describe these processes, as these or very similar methods are prevalent almost all over India.

1. *Boiling and sun-drying.*—Prawns are boiled for about 15 minutes in a large copper vat, in some water to which salt is added in the proportion of 1 seer of salt to 1½ maunds of prawns. When the shells become loose and easy enough for removal, the contents of the vat are emptied into a large bamboo woven basket, placed over another vat, into which the drained salt water is collected for use with the next lot of prawns. The prawns are now spread for drying in the sun on trays made of split bamboo, till they are quite dry. They are then packed in gunny bags and shelled by two men beating the bags with sticks, or by beating half-filled bags themselves on the ground. The contents are then taken out and sifted by winnowing, the powdered shell falling in one heap and the dried prawns in another. Prawns dried in this way are known as 'Siddha chingri' and the powdered shells, which are called 'Bhusi', are sold as manure.

2. *Smoking.*—Prawns are straightaway spread on split bamboo platforms raised on scaffolding and are covered with a loosely woven bamboo matting. Dense smoke is provided from heaps of forest fuel arranged on the ground below the scaffolding. After about two hours the prawns are turned over once or twice with wooden ladles as deemed necessary. Generally, they are sufficiently smoked in about four hours and are then ready for sale. Smoked prawns are sometimes sold with the shells, but generally the shells are removed by trampling on them. In a small smoke-house or 'Khoti' there are generally 12–15 men, but in larger ones there may be as many as 50–60. The men mostly do their own fishing, but sometimes prawns are bought from local fishermen also. This kind of dried prawn is known in the trade as 'Lal chingri'.

3. *Sun-drying.*—Prawns are spread either on the ground or on bamboo mats put out in the sun and are turned over occasionally till they are dry. They are generally sold with the shells, but rarely the shells are removed by trampling on the prawns, after which they are packed in gunny bags. Smaller species of prawns are generally treated by this process, and are known as 'Badami chingri'.

The trade in dried prawns is mostly in the hands of Chittagonian merchants. According to the 'Report on the Marketing of Fish, Prawns, etc. in Bengal',[1] it is estimated that approximately 3 lakhs of maunds of dry prawns are manufactured in the

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[1] I owe it to the courtesy of my friend, Rai Bahadur Dr. S. L. Hora, Director of Fisheries, Bengal, to have been able to consult a copy of this yet unpublished Report.

estuarine districts of Bengal every year. Out of this 30 per cent or 90,000 maunds are Red (smoked) chingri, while the balance is made up of the sun-dried or 'Badami chingri'. This does not seem to take into account 'Siddha chingri' (or boiled and sun-dried prawns) of which, as already stated, large quantities are manufactured in certain districts. Nor does it include the large quantities of 'Bhusi' (or powdered shells of dry prawns) which forms an important by-product of this industry. According to this Report, 15,000 maunds of fish manure, consisting mainly of the shells of prawns, were manufactured in the districts of Khulna and Barisal in the year 1937-38. This product is sold at Rs.1-8-0 to Rs.1-12-0 per maund to foreign or local companies for manuring purposes.

Dry prawns fetch a very high price, as is seen from the figures given in a 'Report on a Survey of Bengal Fisheries'. The prices per maund, presumably, at or near the producing centre, of 'Chamma chingri' or *Penaeus indicus* are as follows:—

	Rs. A.	Rs. A.
(i) *Raw*—		
Rainy season	0 12	
Winter season	1 0	
(ii) *Boiled and sun-dried (Siddha)*—		
Rainy season	20 0	
Winter season	10 0 to	25 0
(iii) *Dry smoked (Lal)*—		
Rainy season	16 0 to	17 0
Winter season	10 0 to	18 0
(iv) *Sun-dried (Badami)*—		
Rainy season	9 0 to	10 0
Winter season	6 0 to	12 0

Somewhat similar figures are given in the 'Fish Marketing Report' for the year 1937-38:—

'Badami' with scales.	'Lal' with scales.	Boiled and dried without scales.
Rs.8 to Rs.10.	Rs.10 to Rs.18.	Rs.20 to Rs.22.

It is thus seen that in the dry-prawn industry, the manufacturer gets his raw material at As.12 to Re.1 per maund and sells the finished product at anything between Rs.6 and Rs.25 per maund, the price varying with the process of manufacture and to a certain extent with the season. All the different manufacturing processes are simple and comparatively inexpensive, wastage as a rule is not considerable and the profits, therefore, are very substantial. Further, according to the 'Fish Marketing Report', the average wholesale price of fresh

prawns in Sir Stuart Hogg Market in Calcutta in the winter months of 1937-38 ranged between Rs.15 and Rs.20 per maund. The Bengal Report gives the prices as Rs.15 to Rs.20 for 'Bagda chingri' or *Penaeus carinatus* and Rs.10 to Rs.15 for *Penaeus indicus* and some smaller prawns. When these prices are compared with those (As.12 to Re.1 per maund) which the poor fisherman gets for his prawns in some of the chief producing centres, one cannot help concluding that some rich middlemen are trying to get richer at the cost of the poor fisherman and the equally poor consumer.

The vastness of the prawn fishing industry in Bengal can be judged in another way also. It is estimated that in 1937-38 the total production of fresh fish in Bengal amounted to 26,068,702 maunds. This vast quantity was made up of 1,729,812 maunds of sea fish, 22,044,660 maunds of freshwater fish and 2,294,230 maunds of crustacea, other shell fish and tortoises, sharks, rays, etc. It is unfortunate that separate figures for crustacea alone are not available, but it can safely be presumed that, if not in quantity, at least in price, the crustacea must have contributed considerably more than half of the monetary value of this catch of over 2¼ million maunds.

As prawn fisheries are run practically the same way all over India, I have described the Bengal fisheries in some detail and will now mention only the outstanding features of these fisheries in other parts of the country.

Although prawn fishing is done on a large scale all along the East coast, the Chilka lake is the most important fishing centre in Orissa. Conditions in the lake are very favourable for the growth and propagation of fish and prawns and especially of species that normally migrate between fresh and brackish waters. Besides using different kinds of nets, the Uriya fisherman has devised a very ingenious method of trapping prawns. He builds from the shore into the lake a bamboo fence, which may be as long as 50 feet and round its farther, or the lake, end, in about three feet of water, he makes a circular or oval enclosure of traps. Each trap is a rectangular basket about four feet high, made of narrow strips of bamboo fastened together by the stem of a creeper. On one side there are four or five apertures, protected inside by converging strips of bamboo, which prevent the trapped prawns from escaping. These traps are set with the apertures facing inwards. The clever fisherman has woven his web with a full knowledge of the habits of the prawns which duly walk into his parlour. Prawns being mainly nocturnal in habit walk at night along the edge of the lake in very shallow water, and when they encounter any obstacle, such as a fence, they try to make their way round it. At the approach of dawn they force themselves into any little crevice or hole that they come across for protection during the day. In fact, the fence leads them to the enclosure and the openings of the traps

are mistaken for crevices or holes into which they walk unawares for protection.

The Presidency of Madras, with its long coast line of about 1,700 miles, excluding indentations etc., has important prawn fisheries in a number of centres. The Government of this Presidency has been long alive to the necessity of developing the fishing industry along up-to-date scientific lines. The pioneer work of Sir F. A. Nicholson in the development of the Madras Fisheries, which was followed by his successors, James Hornell and B. Sundara Raj, has made the Fisheries Department of Madras what it is today, the most efficient organization of its kind in India with an excellent record of good work for the poor fishermen and the fish-eating public of the Province alike.

Among the several advances in fishery practices made by the Fisheries Department of Madras may be mentioned the curing and canning of prawns.

Curing.—In the words of Sir F. A. Nicholson the objects of the Fisheries Department may be summed up in the words 'Better food, more food, more and better fertilizer, better organization'. It is remarkable of the genius of Nicholson that 'better food' is considered more important than even 'more food'. Of all general foods, fish is most liable to taint and most poisonous when tainted and to increase the amount of the catches without improving the methods of its preservation, would only result in increasing dangerous food. As early as 1908 an Experimental Station was opened at Cannanore and was later shifted to Tanur, where experiments in curing and better curing have been conducted continuously to this day. The common and universal method of curing prawns along both the coasts of the Presidency had been of simply strewing the prawns, wholly unsalted, on the beach to dry. The resulting product was always badly tainted or of very strong odour. Moreover, as prawns are mostly caught in large quantities in the monsoon period (e.g. prawns worth Rs.15,000 at low prices were caught in a single day at Tanur in July, 1913) it was often difficult to dry them at all; consequently, while the fishermen got low prices for their catches, the curers ran the risk of losing both their money and their prawns. A very successful method of curing has been devised at Tanur. The prawns are first boiled in salt water which sterilizes and partly cures them, then shelled and salted or brined for a few minutes only and finally semi-dried. This product, the semi-dried prawn, which has become a speciality of Tanur, is suitable for the best tables and keeps perfectly for months. Further, whereas the bone-dry prawns, as produced in Bengal and several other parts of India, are flavourless, hard to cook and digest, the semi-dry prawns of Tanur retain the prawn flavour and with but slight soaking are an excellent and nutritive article of diet.

Simultaneously an advance was made in the drying process also. As prawns are mostly brought to the curing yards on the West coast during the monsoon months of June to August, it is often very difficult to dry them rapidly or sometimes at all. To overcome this difficulty artificial driers were installed at the Tanur Experimental Station. These have worked very successfully and large quantities of prawns that have been boiled and salted with or without shells can be rapidly semi-dried, in spite of the prevailing wet conditions. Constant attempts are being made to improve the product by devising better methods of storing and trasporting it. It was found that cured and semi-dried prawns are after a time covered with a white saline excrescence. This 'rusting', though harmless, is unsightly, but this difficulty has also been solved. The latest outstanding achievement is the use of carbon dioxide as a storing medium. Cured and semi-dried prawns are stored in tins filled with this gas; this prevents all 'rusting' and keeps the prawns in a perfect condition for long periods. The Tanur process, when commercialized, promises a great future for the prawn industry. Bengal and other parts of India, where flourishing dry-prawn industries exist, should certainly adopt the Tanur method of curing and semi-drying prawns. Besides providing a better article than the bone-dry prawn, the Tanur cured prawn has the additional advantage of being fit for canning, when fresh prawns are scarce.

Canning.—Sir Frederick Nicholson with his clear vision realized at a very early stage that canning, properly conducted, is a method eminently suited to a tropical country like India, especially for fish of all kinds that taints so readily. Fresh fish can never be both cheap and good up country so long as ordinary refrigeration by ice is the only method available. The only alternatives are curing and canning. Light-cured fish and prawns are a fair substitute for fresh fish, but curing is difficult to carry out in such a way that the products are thoroughly digestible, wholly acceptable, and of good keeping quality. Pickled fish and prawns, that is, wet packed in salt, are another good substitute, but the cost of barrels and freight is rather high and the product keeps in a good condition only for a limited period. This naturally brings us to canning, with the manufacture of fish paste as an additional line. Properly canned goods keep in a good and wholesome condition for very long periods; in fact it has been found that they improve by keeping, and reputed French canners of sardines are known not to issue their products till six or twelve months after manufacture. Further, canning makes us more or less independent of bumper and lean years and appears to be the best method of providing a nutritious and wholesome article of diet to people in all parts of the country, at all seasons of the year and at prices not higher than those of the so-called fresh fish in places at some distance from the fishing centres.

In the Madras Presidency experimental canning was started by the Fisheries Department at Calicut in January, 1912. It was confined to sardines, mackerel and prawns, and even in the first season was declared a great technical success. Mackerel and prawn pastes were also successfully made. The demand by the public for fish and prawns canned at Calicut and later at Chaliyam near Beypore was so great that, even as early as 1913-14, it was found impossible to fulfil all orders. The Madras Fisheries Administration Report for 1914-15 showed that, judging by repeat orders and other evidence, this experimental work had been highly successful, and there was obviously a large unsatisfied market for pure and cheap food manufactured on a commercial and not on an experimental scale. Year after year the cry of unsatisfied demand was repeated and, though production was considerably increased, the market asked for more. During years when prawns were scarce in the catches, partially cured and semi-dried prawns from Tanur were canned and made into paste. This went on for a number of years, but the effects of the slump resulting from the last war began to be felt. Though canning still remained an unqualified technical success, stocks began to accumulate in the cannery. In 1924-25 manufacture was severely curtailed by stopping the cannery for a part of the year. Judging by the Administration Reports, one cannot help feeling that, though the technical achievements of the Beypore cannery were indeed great, the marketing aspect of the enterprise did not reach the same standard of perfection. 1925-26 continued to be a bad year. The cannery did not work, and when the question of its permanent closure came up for serious consideration, Sir F. A. Nicholson strongly advised its retention for 'promoting food production and distribution, and developing industry, trade and intelligence'. But for one reason or another the cannery failed as a Government concern, and passed recently into the hands of a private company. Thus the scheme so brilliantly conceived by Sir F. A. Nicholson and so tenderly fostered by him and his successors came to a premature end. Though it did not completely fulfil its objects, it has definitely shown that canning can be successfully done in India, and that with proper attention paid to both the technological and marketing aspects of the industry, it can provide good and wholesome food to the people at prices that are not in any way excessive.

Lack of reliable fish statistics in India has always been keenly felt, but the Madras Fisheries Department has fulfilled this need to a certain extent, for during the last many years it has been publishing very valuable statistics for the West coast. The Department has under its charge over a hundred fish-curing yards, of which half or a little more than half are on the West Coast. The information on which the statistics are based is collected by the yard officials and, though no claims of

completeness or exact accuracy are made, the figures published are of great value. For one thing they show that prawns occupy a very high place, both in quantity and value, in the fishing industry along this coast. Unfortunately, I have not been able to get figures for the last several years, but those given below for the six years, 1925-26 to 1930-31, show the great importance of prawns in the industry.

Year.	Rank according to weight.	Quantity *in mds.*	Rank according to value.	Value in rupees.
1925-26	V	88,763	V	2,30,869
1926-27	III	177,468	III	4,92,920
1927-28	V	74,024	VI	2,00,404
1928-29	III	129,824	II	2,39,007
1929-30	III	141,671	III	2,82,020
1930-31	I	186,141	II	3,33,083

The extreme range of prices of the different kinds of fish at or near the curing yards is also given. In the case of prawns it is seen that very often the minimum price is only a few annas a maund. In one year at a particular yard, the minimum was no higher than Re.0-4-10 per maund, while Re.0-8-0 a maund seems to be the usual minimum at many of the yards. The maximum price per maund in most yards seems to range between Rs.5 and Rs.8, though in one exceptional year it went up to Rs.30 per maund at one yard.

The statistics given by Moses for the markets of Madras are still more remarkable. These figures were collected from 21 markets in Madras and cover a period of one year from 16-7-1921 to 15-7-1922. According to these figures, 'Both in quantity and value the crustaceans are of greater importance than any kind of fish in Madras. The prawns top the list, while the crabs come next. Shrimps, however, occupy a low place'. His figures for these three kinds of crustaceans are as follows:—

	Rank according to weight.	Quantity in lb.	Rank according to value.	Value. Rs.	A.	P.
Prawns ..	I	678,654	I	91,118	7	0
Crabs ..	II	338,584	II	40,243	15	0
Shrimps ..	XX	33,004	XXIV	3,694	8	0

Moses has also given the average prices at which sellers purchased different kinds of fish from middlemen or from fishermen direct. For prawns he gives the figure of Re.0-2-3 per pound, or roughly Rs.11-8-0 per maund. The price that the consumer has to pay is of course much higher. When this figure of Rs.11-8-0 per maund, the price prevailing in Madras, is compared with Re.0-4-10 per maund that the poor fisherman sometimes gets for his prawns in some places on the West coast, the wages of honest labour appear to be scanty.

In the backwaters of Cochin and Travancore a flourishing prawn industry has existed for about 25 years. Extensive fishing is carried on in the sea and in the backwaters, but the paddy fields that adjoin the backwaters all over provide the best fishing grounds. Panikkar has given an excellent and detailed account of prawn fishing in Travancore and I need not summarize here all that he has said. I will only refer to the practice of 'prawn culture' in this area, which he has so well described.

In Travancore generally there are two seasons for paddy crop, one from December to March and the other from July to October. In large areas adjoining the backwaters paddy is cultivated only in the July–October season, and in the other season prawns are cultured in these fields. At the end of the north-east monsoon, when the paddy crop is over, say by the end of September, the fields are free and water from the backwaters is allowed to enter them freely. With the lowering of the water level after the October–November rains, the bunds surrounding the fields are strengthened and communication between the fields and the backwaters and canals is restricted to a few sluice gates. These gates are fitted with adjustable planks, so that the water level in the fields can be easily regulated. The water in the canals is now brackish and tidal effect is quite marked. The sluice gates are kept open at high tides and brackish water enters the fields freely, bringing in large numbers of young prawns that abound in the backwaters at this time. With the onset of the ebb the gates are closed. This goes on till the fields are well stocked with prawns. The prawns are allowed to grow in the fields for two or three months and are fished when they are of a size of 4 to 5 inches. Fishing generally starts at the end of December or the beginning of January. When the level of water outside the fields begins to fall with the onset of the low tide, the planks of the sluice gates are removed one by one. The water forces its way out of the gates and the prawns that are carried with the current are safely bagged into a large, conical, close-meshed net that has been fitted outside enclosing the sluice gate.

Extensive fishing is carried on in the backwaters also. Two country boats are lashed together, supporting a net between them. The boats are taken where shoals have been located and prawns trying to swim through are trapped in the net.

In Travancore there is a fairly large dry-prawn industry also, but the methods followed are very primitive. Prawns are either sun-dried or boiled and sun-dried, but the latter practice is more in vogue. Boiling is done without the addition of any salt and the resulting product has poor keeping qualities and is unsatisfactory in many ways.

The prawn fisheries of the Bombay and Sind coasts have been very well described by Rai. He estimates the total

production at 12,000,000 lb., valued at about Rs.25,00,000. In Sind the prawn fishing season is from November to January and fishing is mostly done in creeks at comparatively short distances from the shore. Large quantities of dry prawns are exported, and Burma used to be the biggest market. In 1929-30 dry prawns and prawn shells worth Rs.11,59,797 were exported from Karachi alone.

On the Bombay coast also the fishermen mostly restrict their activities to waters within 10–12 miles from their home ports. The nets used are more or less similar to those employed in Bengal and other parts of India. *Bokhsi* and *Dol*, like the *Behundi jal* of deltaic Bengal, are designed to work with the tides. *Bokhsi* is only about 30 feet long, with a mouth of about 8–10 feet in diameter and several of these are sometimes used in a series in shallow waters. *Dol* is a much bigger net and may be as much as 700 feet in length, with a mouth having a circumference of 300 feet. This is used in comparatively deep waters. The tide sweeping through the mouth brings in the catch and the nets are emptied with the turn of each tide.

Large quantities are consumed fresh and sent inland packed between layers of ice, and whatever is left is either sun-dried or boiled. Sun-drying is the commoner method and is carried out in the usual way. Boiling is common on the Sind coast. A little salt is added to the sea water in which the prawns are boiled for about half an hour. They are then spread on drying platforms and in a couple of days, when quite dry, shelling is done by 'threshing' with sticks. The product keeps well for a number of months, but has all the drawbacks of bone-dry prawns, already mentioned.

Lobsters are also fished on a small scale along these coasts, the fishing season being chiefly from November to March. In addition to the usual 'lobster pot', Bully nets, which are like small tow-nets, with the bait tied in the centre, are used. It is estimated that on the Bombay coast alone 60,000 lobsters worth about Rs.15,000 are caught every year.

I have said enough to give you an idea of the prawn fisheries of our country, of their vastness, of the methods employed by the fishermen and the manufactures, and of the few advances that have been made in certain places. On the whole, it is a dismal tale. The fisherman is employing the methods that his forefathers used generations ago. Very little, if any, improvement has been made in his gear or in his stock of knowledge. He is still as poor and as ignorant as his forefathers were and the few attempts that have been made to ameliorate his lot, as has been done, among others, by the Madras Fisheries Department, have barely tinkered with the problem. He still fishes in inland creeks and on a narrow coastal belt and is hardly aware of the great wealth that is waiting to be exploited in the deep. Even if he knew it, his boats and appliances are hardly suitable for

work in depths greater than a few fathoms, nor has he the means to equip himself any better. For generations he has been in the grip of a ring of money-lenders and is forced to sell his catch to them, sometimes, at ridiculously low prices. The handling of the catch, which is often very considerable, is equally unsatisfactory; a part of it is consumed locally, a part sent inland with or without ice and the balance is dried. Drying again, as we have seen, is done in a very primitive way and generally results in a product which is far from satisfactory.

This tale becomes all the more dismal when we compare our fisheries with those of some of the more advanced countries. Take, for instance, the Cape Crawfish industry of South Africa. The crawfish has been known to exist abundantly on the west coast of Africa from a very long time past, but attempts to exploit it commercially since 1874 proved expensive failure up to modern times, when these very failures paved the way for the present success. Now the crawfish canning industry has been fully established. The value of canned crawfish in the Union of South Africa alone in 1932 was estimated at £450,000. In addition, frozen crawfish tails, valued at a little less than a hundred thousand pounds, were exported. All this has been achieved by sustained researches, both technological and scientific. The earlier difficulties in satisfactory canning encountered by the pioneers have been completely overcome and the product is now so good that in 1934 one large cannery paid out the sum of seven shillings and six pence, representing roughly ·0003 per cent of their total output, in repaying for bad and damaged tins. Scientific research has fully kept pace with technological advances and we now know a great deal about the anatomy, reproduction, development, natural food, migration and life-history of this useful crustacean. Beds, where the crawfish is found in quantities sufficiently large to be exploited commercially, have been fully charted and protective legislation, based on the results of scientific research, has been framed and passed.

Or take the prawn industry of Norway. In the very soft bottom mud of the fjords of south-western Norway, at depths ranging down to a hundred fathoms or more, a prawn, *Pandalus borealis*, was discovered in enormous numbers towards the end of the last century. Dr. Hjort, the great naturalist of Norway, after many unsuccessful attempts, devised a trawl that could be dragged along the bottom without filling with mud. The result of the discovery and the improvement in the fishing gear has been that whereas before 1898 *Pandalus borealis* was scarcely known, except to the scientist, it now provides the basis of a very flourishing industry. The catches in recent years have amounted to as much as four thousand tons annually and over 60,000 fishermen find employment in the industry. As only a small part of the catch is consumed locally, a large export trade in fresh

and canned prawns has been established. The development of the prawn industry of Norway is indeed a very striking example of the practical value of scientific research.

The shrimp industry of California may be mentioned as another example of the value of technical research in the fishery industry. In the up-to-date factories the shrimps, cooked in self-regulating boilers, after being automatically tipped over into hoppers, go into mechanical shakers where they are separated into large and small individuals. The large ones go down a chute to a table where they are hand-picked for culls, put into barrels and are sold fresh. When the supply is too large and the demand in the market small, a galvanized wire cylinder is placed in the centre of the barrel for ventilation and the barrel put in cold storage, where it is frozen solid until the market improves or further catches become meagre. The smaller shrimps are piled on a long table covered with square-meshed wire and a current of hot air is forced through for drying them rapidly. The dried shrimps are now run into a rotary tumbler which breaks them up, and are fed finally through a blower which separates the meat from the broken shells, etc.

I hope enough has been said to show the advances that scientific and technological researches have brought about in the fisheries of other countries. That there is an urgent need for such researches in India also goes without saying. In the inshore waters of our vast coast line, in the connected extensive estuaries, backwaters and lagoons, and in the network of great rivers all over the country which teem with fish of all kinds, we have a source of great wealth. The catches which the Indian fisherman is able to get even with his archaic appliances compare favourably with those of more advanced countries. The real problem is not so much the production of more fish, though that is a very desirable object, but the proper preservation, distribution and utilization of such fish as are available. Quick freezing refrigeration, cold storage, speedy transport, better sales organization, besides helping to raise the economic condition of our fishermen would make this valuable food available in adequate quantities to our people in a wholesome condition and at cheap prices. The introduction by the Bombay Fisheries Department of fast motor boats for transporting the catches from the fishing grounds to the landing places has proved a great success and there is no reason why this cannot be tried in other places also. Better sale organizations are very badly needed in the interests of both the fisherman and the consumer. In Bengal, it is stated, that there are invariably three intervening middlemen and one retailer before the fish reaches the consumer. This should certainly be stopped and better facilities arranged. Sun-drying, which is the commonest method in vogue, is very wasteful and at best results in a very unsatisfactory product. Attempts should be made to popularize

smoking and boiling. The Tanur method of curing and semi-drying is a step in the right direction and extensive propaganda should be carried on to make this process popular. Artificial driers should be installed either by the Fisheries Departments or by fishermen's co-operative societies to make the manufacturers independent of weather conditions and thus stop large-scale wastage that now takes place. Canning should be taken up on a wide scale in Bengal, Madras, Sind, and in several other places. It is only experimental canneries, with trained technologists, biochemists and marketing experts on their staff, started in some of the chief fishing centres of the country under Government auspices, that would lead the way to the establishment of canning as an important industry in our country in a comparatively short time. This will not only supply our internal requirements but will also result in a large export trade.

The improvement of the fishing craft and fishing gear is another desideratum. The Indian fisherman must be helped to use better boats and larger and better nets if he is to take an adequate and fairly regular toll from the sea. Experiments in deep-sea trawling conducted by the Bengal, Madras and Bombay Governments have shown that trawling can be a successful proposition in the deeper waters off our coasts.

Simultaneously with the steps outlined above, or perhaps even prior to these, intensive and sustained scientific research should be undertaken on the animals that form the basis of our fisheries. At present we do not know the complete life-history of a single species of prawn or fish. We should make a complete study of all our commercial species, and know fully their bionomics, morphology, food-habits, migration, reproduction, life-histories, rate of growth and other allied problems. The fishing grounds along our coasts should be charted, and the conditions which favour the production of fish in those areas investigated. Legislation based on the result of these scientific studies should be strictly enforced with a view to safeguard the preservation and continuance of the fishery. All this is a big task requiring the energy of a band of Zoologists, assisted by experts in allied sciences, working for many years, but the potentialities of our fisheries are so great that any money and effort spent on their improvement will be well worth while.

Amelioration of the lot of the fishermen should not be lost sight of in any programme of fishery development, as our progress will be judged not only by the quality, quantity and the price of fish available to our people, but by the conditions, moral and material, under which our fishermen live.

I am afraid I have outlined a very ambitious programme, but in all other countries of the world, where fisheries are scientifically run, all this has been and is being continuously done. In my opinion, the first step in India should be the setting up

of a central fisheries research organization, where intensive research on problems connected with fisheries will be carried on. The Imperial Council of Agricultural Research has done a great deal of useful work on the improvement of our agriculture, and a section of it, under the Animal Husbandry Commissioner to the Government of India, looks after, among other things, the fisheries of the country. The work so far done by this section on the improvement of our fisheries is, however, hardly comparable with that of the main body on agriculture or commensurate with the requirements of the country. Fishery research is a whole-time job and the problems connected with it are too numerous and too involved to be satisfactorily handled as a subsidiary activity of a section of the Imperial Council. Like agriculture, fisheries should have an Imperial Council of Fisheries Research under the scientific control of an expert Fisheries Officer, with a band of scientists working on its staff, with technologists trying to solve the difficulties experienced under varying conditions all over the country, with marketing experts always keen to devise means for better distribution and better utilization, and with the whole body alive to the ideal of providing 'better food, more food, more and better fertilizer, better organization', and last but not the least, to the improvement in the moral and material conditions of the poor fisherman, for on his well-being will ultimately depend the prosperity of the industry.

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SECTION OF ANTHROPOLOGY AND ARCHAEOLOGY

President :—N. P. CHAKRAVARTI, M.A., PH.D. (CANTAB.)

Presidential Address

(*Delivered on Jan. 4, 1943*)

EPIGRAPHY AND ANTHROPOLOGY

This is the first time in the history of the Science Congress that an epigraphist with no pretensions to anthropological qualifications has been chosen to preside over the section of Anthropology and Archaeology and I offer my sincere thanks to the authorities for giving me this opportunity in spite of the many shortcomings which I have. At the very outset, however, before I pass on to the main theme of my address, I would like to pay with you all who are present here, our humble tribute to the well-known scholars in archaeology and anthropology who have recently passed away. In this country we have lost from our midst Rai Bahadur Sarat Chandra Roy and Rai Bahadur Ramaprasad Chanda in whom we had two prominent workers in the field of anthropology and archaeology. Rai Bahadur Sarat Chandra Roy's investigations on the primitive tribes of Bihar and Orissa earned for him tributes which he richly deserved and anthropologists, particularly those in India, will ever remain grateful for the services he has rendered in the cause of anthropological studies in general and for the numerous articles in the *Man in India* of which he was the founder-editor, which have thrown light on many obscure corners of anthropological studies in this country. It is, however, a matter of gratification that the volume of 'Essays in Anthropology' prepared in his honour by his friends and colleagues could be got ready and presented to him just in time before his death. In Rai Bahadur Chanda we have lost a sound archaeologist and an eminent scholar in anthropology. He could not confine his activities within the four walls of the school room where he started his career as a teacher. He was one of those to whom the Varendra Research Society owed its conception and which Institution he carefully nurtured through its early years of existence like a dutiful and fond mother. The University of Calcutta, where he spent several years as a teacher in the Department of Anthropology, owes its gratitude to him for the help he rendered in the framing of the syllabus in the newly created Department of Anthropology at a time when Anthropology as a subject of scientific study was hardly known in this country. His work in the Archaeological Department, which he joined later in life, has received recognition not only

from his colleagues in the Department but also from eminent archaeologists abroad. Even in his retirement in spite of the failing health he kept up his studies of a subject he genuinely loved.

Among the European scholars I have to mention the name of Sir Flinders Petrie, the veteran archaeologist, whose name is well known to archaeologists all over the world and who by his decades of experience has given altogether a new orientation to the study of archaeology.

Another personality we have lost not long ago is Sir Arthur Evans. Starting his life as a numismatist, when he visited Greece in 1893 he came across some prism seals engraved with hieroglyphs which had hardly received any attention from archaeologists till then. In the course of investigation on this script and establishing its relations with those found in Anatolia, Cyprus and Egypt he, in 1894, visited Crete from which place the gems were stated to have come originally. It was here that he came in contact with the great prehistoric monuments—such as the walls of Goulas in Mirabello and the site of Knossos near Candia. The results of his excavations at the palace site which continued for seven years are now known to us from his *magnum opus* 'The Palace of Minos' which reveals the wonders of Minoan culture and his was perhaps the most spectacular archaeological discovery in the early years of the present century. He dedicated his life to the cause of archaeology and the benefactions which he has made in its interest are on a munificent scale.

Another scholar in whose death, due to enemy action, Indian Archaeology and History of Art have suffered a grievous loss is Monsieur Joseph Hackin, the Director of Musée Guimet in Paris. When the war broke out he was out in the East as the Director of the French Archaeological Mission in Afghanistan. He is remembered best of all by his work at Bamiyan and Begram where he brought to light art treasures of inestimable value which have thrown new light on the Indian, Chinese, Hellenistic and Greco-Roman cultures.

Another scholar whose death anthropologists mourn all over the world is Sir J. G. Frazer. Posterity will remember with gratitude his work on social anthropology as revealed in the monumental volumes of 'The Golden Bough'.

I should also mention here the names of two other scholars who passed away only recently, viz. Sir Francis Younghusband, the well-known explorer and Mr. B. C. Majumder, the ethnologist and archaeologist.

We are now in the fourth year of a world war, the kind of which the world had not experienced before, and not for centuries has the enemy been so near the gates of our country as he is today. At such a time it is but natural that progress in the study of cultural sciences like archaeology and anthropology

would receive a setback. This is the main reason why archaeological work has been at a standstill in many of the Indian States where excellent work was being done in the past. It is understood that though very few of the States like Hyderabad and Mysore had an opportunity to explore fresh fields of activity during the past year, most of them have been utilizing this opportunity in studying the finds already made during previous years.

For the same reason, the Archaeological Survey of India has also been hit to a certain extent and had to curtail its activities. Owing to financial stringency new works could be undertaken only to a very limited extent and due to acute paper shortage most of the departmental publications have been stopped for the duration of war.

In spite of all these and other difficulties in the way during the year 1942, the Archaeological Survey of India, however, carried on its activities as much as possible under the present disturbed conditions in India. The Director-General had in a lecture before the last session of the Congress held at Baroda indicated the scope of a prehistoric expedition in Gujarat which was arranged by the Archaeological Department with the co-operation of a few other institutions and individual scholars. The area chosen was a part of the Sabarmati Valley mostly lying within the Baroda State. Except the pioneering work done by R. Bruce Foote nearly fifty years ago, who discovered the oldest crude implements on the banks of the Sabarmati near Vijapur, very little investigation was carried out in this part of the country before this expedition was undertaken by the Archaeological Survey. The materials collected during last year's expedition are now being studied and the report, when ready, is likely to throw some interesting light on the history of the Palaeolithic, Neolithic and Iron ages in India. Unfortunately, due to the political conditions prevailing in India, it has not been possible to continue the expedition during the present winter season, but it is hoped that as soon as conditions improve the thread of exploration will be picked up again at the point where it was left at the beginning of 1942.

A systematic excavation at Ahichchhatra, the capital of the ancient Pañchāla country, identified with modern Ramnagar in the Bareilly district of U.P. was continued for the second season during the winter months of 1941-42 and has again been resumed during the current season and it is hoped that further interesting light will be thrown on a period of Indian history about which we are still in the dark and the complexity of which has often puzzled the Indian archaeologists and historians. During the last autumn and winter, excavations were carried on primarily in four sites which have been designated AC III, AC IV, AC II and AC V. In AC III the excavation was carried to 20 ft. below surface and three strata were exposed. The first two

revealed only blocks of residential buildings of a later period, while the third exposed the remains of a temple which was built during the Gupta period. The temple was, however, reconstructed on two or three different occasions with slight modifications of the original plan. It was undoubtedly of Śaiva origin as some of the terracotta images unearthed, such as those of Śiva, Pārvatī, Cāmuṇḍā and Sūrya, would indicate. The latest occupation of the site was evidently contemporaneous with the age of the hoard of Gadhaiyā coins of Vigraha and Ādi-Varāha types (9th to 10th centuries A.D.) which yielded to the spade. The site seems to have been deserted at a subsequent period.

In AC IV also five strata were laid bare, of which the third coinciding with the Gupta period, was interesting in that an official Gupta sealing belonging to the provincial administration of Ahichchhatra was discovered here which made the identification of the site with ancient Ahichchhatra quite definite. The fourth stratum belonged to the later Kushān period and the fifth, the last stratum exposed so far, to the Kushān period, if not to the Śuṅga period as the finds of coins only of the Pañchāla type might indicate.

Here a word may be said about the lay-out of this ancient city. The city was enclosed on all sides by massive ramparts re-inforced by a network of bastions. There is a clear indication that the original ramparts were of mud which were at a later period encased by bricks. The ramparts show a large number of gaps and it is probable that some of these at least mark the position of the city gates. This city, which was well fortified, was divided into two sections, eastern and western, by a thick partition wall which was probably built during the Gupta period. From the bastions attached to it, its purpose seems to have been defensive. In the absence of further proofs it would perhaps be too premature to risk any theory as to whether this wall was erected as an additional defence by Achyuta, the ruler of Ahichchhatra, to prevent an attack of the great Gupta conqueror Samudragupta or by a later ruler to stem the tide of the Hūṇa invasion to which the Gupta empire was subjected in the fifth century of the Christian era or whether it was simply meant to be a partition dividing the richer from the poorer quarters of the city.

AC II represents the site of a huge temple, originally built in the Gupta period and subsequently enlarged and reconstructed on different occasions. In its enlarged state, the temple occupying the site of AC II measures about 108 ft. square, rising in four diminishing tiers, with a *pradakshiṇa-patha* or circumambulatory path in each tier. Similar features are noticed in another temple site (AC I) at Ahichchhatra, which is the highest mound at the site and actually forms a landmark in the surrounding country. Undoubtedly these were two of the nine Deva temples which the Chinese traveller and scholar Yuan Chwang

found at Ahichchhatra when he visited the place in the seventh century A.D.

At the site AC V the excavation was carried to the virgin soil which was reached at 77 ft. below datum. The earliest settlement here definitely belongs to the Śuṅga period as evidenced by the discovery of a number of exquisite terracotta plaques belonging to this period associated only with the coins of the punch marked, uninscribed cast and Pañchāla types and also a personal sealing inscribed in the characters of the early Śuṅga period.

Near this site and against the city wall was found a collection of terracotta figurines most of which are of religious character. All the statues are of Brahmanical deities and their date cannot be earlier than the eighth century A.D. The majority of them are apparently representations of the Mother Goddess. Some of them have a child in their lap but about half a dozen of these bear not one but three heads. Among them was also an image of Mahishamardinī. All the figurines were of female deities with the exception of two, and of these two male figures, one appears to be that of Narasiṁha and the other is the torso of a seated figure and though belonging to a much later period, reminds us of the royal Kushān statues from Mathura.

An exploration tour which Sir Aurel Stein carried out in the winter of 1941 along the dry bed of the Ghaggar or Hakra in the desert tracts of Bikaner and Bahawalpur States and the results of which are expected to be shortly published in a *Memoir* of the Archaeological Survey, is of great historical and geographical interest. In course of his tour, Sir Aurel surveyed the bed of this river, which he identifies with the Sarasvatī of the Vedic texts, for a distance of close on 260 miles and discovered a large number of new sites dating from the Chalcolithic to the Kushān period. The sites traced up to a short distance below Suratgarh in the Bikaner territory, of which the more important ones are Rangmahal, Munda and Suratgarh, date from the Kushān period as is evident from the definitely datable sculptured terracotta panels, painted and incised ceramics and Kushān coins found at these sites. Extending from a short distance below Suratgarh as far as Marot in Bahawalpur territory, the sites show an inferior type of decorated pottery, unpainted and having only impressed patterns of a very simple kind. These ceramic remains are assignable to a period which falls between the Chalcolithic and early historic times. The numerous old sites below Marot stretching in a continuous chain as far as Derawar up to which the explorations were carried, invariably belong to the Chalcolithic period as is clear from the discovery on their surface of painted pottery of known prehistoric types, chert and flint blades, faience bangles, terracotta bulls, toy-cart frames, semi-baked clay cakes, etc. Trial excavations were conducted only at two sites, Sandhanawala and Derawar. The

former was a site closely resembling Amri discovered by the late N. G. Majumdar, as it showed typical finds of the Mohenjo-Daro culture such as black-on-red painted pottery sherds incised with characters, etc., in the upper stratum while the lower stratum which was separated from the upper by an intervening debris yielded the pale thin ware of the Amri type, painted with mostly geometric designs in sepia or chocolate on buff or cream coloured background. Derawar is a much more extensive site dating from the Mohenjo-Daro period and the trial digging here was confined to exposing the funerary articles comprising pottery in a low, flat cemetery mound.

From the careful topographical observations made by him, Sir Aurel succeeded in tracing another dry river bed of a branch of the Sutlej which joined the Hakra bed little above Fort Abbas near the border of Bahawalpur State. As Chalcolithic sites are traceable only below this junction, Sir Aurel concludes that the prehistoric occupation had been abandoned when the Sutlej branch, which carried abundant water from the great snow-fed river to the Ghaggar bed, had ceased to flow towards the close of the Chalcolithic period. These researches have a direct bearing also on the problem of desiccation in Asia which has its wider interest for students of both history and geography.

It was three years ago, when Mr. K. N. Dikshit, the present Director-General of Archaeology, was elected President of this section in the Madras session of the Congress, that he pointed out the clear connection that exists between the two of the latest and therefore the youngest of the sciences, viz. anthropology and archaeology. In the same way as the study of anthropology cannot be wholly disconnected with the study of archaeology, archaeology as a science cannot stand apart from epigraphy. The alphabets we know today in the civilized countries of the world are highly developed artificial forms of writing which has passed through various stages of development for millenniums. From the earliest time there was the hankering of men to convey their ideas to others far apart in space and time. The prehistoric remains supply us with ample evidence how in the past, far remote from today, the primitive man depicted with the help of a sharp-pointed flake on bone, horn, schist and other materials representations of his own kind or of various wild animals he came in contact with in the course of hunting to which he had to take recourse sometimes for self-preservation and sometimes for his own sustenance. Such representations, though mostly consisting of rude etchings and paintings, have been found over very widely distributed areas comprising different continents of the world and a very wide period beginning from the Palaeolithic age. Many of such drawings may suggest actual portraits or even caricatures or they might have been associated with totems. Yet it would not perhaps be correct to deny emphatically that some of them

at least were not an attempt to depict some memorial event in the history of a particular tribe. R. H. Mathews, who has made an extensive study of the rock paintings and carvings particularly in Australia, says: 'Although it will be better not to attempt to suggest meanings to the groups of native drawings until a very much larger amount of information has been brought together . . . . still when we know that drawings such as these by uncivilized nations of all times, in various parts of the world, have ultimately been found to be full of meaning, it is not unreasonable for us to expect that the strange figures painted and carved upon rocks all over Australia will some day be interpreted. Perhaps some of these pictures are ideographic expressions of events in the history of the tribe; certain groupings of figures may portray some legend; many of the animals probably represent totems; and it is likely that a number of them were executed for pastime and amusement.' And what is applicable to Australia is equally applicable to any other country, conditions being similar.

The succeeding stages through which the development of the alphabet has passed are, like the history of the Mankind, varied. Several of these stages are indeed well marked though in the earliest of these writing was independent of the spoken language. The principal stages in this development may be defined as four, viz.: (1) The Memonic or memory-aiding stage, illustrations of which can be found in the knot reckoning known as the Peruvian Quipus or the reckoning by means of beads of different colours and shells arranged in various ways on cords or strips of leather or similar other fastening materials as are mostly prevalent among the North American Indians (Wampum belts), a practice followed even today among some of the ancient tribes. This is practised in its simplest form in this country even now in the villages among the illiterate, though it is confined only to counting. The supplier brings his or her supply to the customer. After the supply has been made a mark is put daily by the supplier or the customer in the presence of each other and when payment has been made after some time, say a week or so, the marks are struck out by a line across. (2) Pictorial, i.e. a stage when the pictures of the intended objects were drawn which therefore needed no further explanation. (3) Ideographic stage where the drawing represented an idea rather than a word. This was further developed by additions of a purely phonetic value and such developed forms of ideographs were used by the Sumerians, the Babylonians in their cuneiform script, the Egyptians, the Hittites in Asia Minor, the Chinese in the Far East, the Mayas and Aztecs in America and in this country by the people of the Sind Valley who have left a high standard of civilization, more advanced than their so-called Aryan conquerors. This last-mentioned script, as you all know, has been found on the numerous seals discovered at Mohenjo-Daro and

Harappa. Unfortunately, very little is yet known of this script. Many theories have no doubt been put forward one after the other and though some are still holding the field, most of them have already passed into oblivion. We may give certain values to particular symbols and interpret the ideographs accordingly. It is quite true that a Rosetta stone is not discovered every day and we may have to wait a long time yet till a bilingual document containing a text in this script of the Sind Valley and also in some other known script and language is forthcoming. I do not therefore discourage any plausible theory to be put forward but to be definite the epigraphist must have other evidences to prove his theory.

It may, however, be argued that similar difficulties were experienced in the past in the decipherment of other scripts including the Brāhmī script which is the parent of all the Indian alphabets known today. But one factor at least, viz. the language, was known in most cases. We do not know what was the language in which the inhabitants of the Sind Valley spoke and wrote. Certainly the language was not Aryan, if we have to believe the accepted theories of the migration of the Aryans into India and the date of the Rigveda, the earliest of the Vedas. Even if the language belonged to the Dravidian or the proto-Dravidian family, which is not impossible taking everything into consideration, we would perhaps not be justified in finding its close relationship with the present-day Tamil, till we are in a position to prove that there has been no marked variation in the language during the last four or five thousand years—a theory which would clash with facts known from philological studies.

We all know what direct help can archaeology give to the study of anthropology. But how far can epigraphy help us in such a study? There are three main factors in the study of problems connected with human history, viz. environments, race and culture. Epigraphy is certainly not helpful in the study of the antiquity of man or for the study of environment or anthrogeography, or even for the study of race or physical anthropology; but like archaeology it is invaluable for the study of cultural anthropology consisting of language, material culture such as arts and crafts and moral culture, e.g. social institutions. Whatever may be the truth, it is almost inconceivable to dissociate man with language. Language, however defective it might have been in vocabulary and power of expression, was the most precious possession a man had from the beginning and the prerogative to talk was his own right. But its greatest defect was that though it was useful for communicating one's sorrow, happiness, thoughts and experiences to those who lived with him it was of no use to his descendants who came after he was dead or his dear ones who lived away from him. It is true that in the remote past oral traditions played a prominent part in handing down the intellectual and spiritual records of

man's past to successive generations but this system could not but have its own limitations and in the course of time these traditions must have lost most of their authenticity. Memory, however stupendous it might have been with our forefathers of the far ancient times, was not altogether 'infallible' and therefore could not always be depended upon. In the words of Clodd: "We have only to assume the absence of any medium whereby we could communicate with friends at a distance, or whereby the now complex and countless dealings between man and man could be set down and every transaction thus 'brought to book', to realize the hopeless tangle of our social life. All that memory failed to overlap would be an absolute blank; the dateless and otherwise uninscribed monuments which the past had left behind would but deepen the darkness; all knowledge of the strivings and speculations of men of old would have been unattainable; all observation and experience through which science has advanced from guesses to certainties irretrievably lost; life could have been lived only from 'hand to mouth', and the spectacle presented of an arrested world of sentient beings. Save in fragmentary echoes repeated by fugitive bards, the great epics of East and West would have perished, and the immortal literatures of successive ages never have existed. The invention of writing alone made possible the passage from barbarism to civilization, and secured the continuous progress of the human race. It is solely through the marvellous perfecting, through stages of slow advance, of a scripture that 'cannot be broken', that the past is as eloquent, as real as the present. 'The pen is mightier than the sword' in accumulating and preserving for both gentle and simple the store of the world's intellectual wealth, unto which 'all the things that can be desired are not to be compared'." Is it any wonder, then, that the origin of writing should be ascribed to the gods of the ancient folks—who gave them light and darkness, thunder, rain and storm, who brought happiness, distress and disease upon them, who had, in short, the power of life and death over them? In the West, according to Greek legends, Cadmus brought the alphabet from Phoenicia to Greece; according to Irish legend Ogmios is the inventor of writing and the Northern Saga attributed the invention of the runic alphabet to Odin. In the East, we learn from an Assyrian inscription that the cuneiform characters were a revelation from the god Nebo; Thoth was the scribe of the gods according to the Egyptians and the oldest form of the Egyptian writing was called 'the divine'. The credit of the invention of the Chinese script goes to the sage Ts'ang Chien and in our own country the earliest writing is known as Brāhmī, i.e. originating from Brahman, the Creator Himself.

Now the question arises—in what way can Indian inscriptions help in the study of ethnology? The material for ancient

Indian history is scattered and has to be culled after careful sifting from a vast range of literature, traditions and a few accounts of foreign travellers which have come down to us in a complete or an incomplete form. The most valuable part in the reconstruction of Indian history is therefore played by archaeology, through which we have to learn of the culture of our ancient forefathers and in the study of which inscriptions and coins offer the most useful help. The inscriptions are certainly invaluable in the study of history by the direct evidence they produce but they also offer, though indirectly, valuable information about ethnic tribes, their customs and social organizations. One great advantage of epigraphs is that they usually record events not far removed in age from the records themselves and there cannot be any question about the authenticity of the information they supply and this is particularly so in case of the early records where only contemporary events find a place. In later records, we no doubt sometimes find matter that is extraneous but in these also the events relating to the contemporary period are usually correct and in many cases their authenticity can be checked from other sources. I shall here confine my remarks to the Indian inscriptions alone and only to the period between the third century B.C. and the early part of the sixth century A.D. for which we have little information from sources other than archaeological.

The earliest inscriptions from which we can get valuable data about certain ethnic tribes, foreign and Indian, date from the third century B.C., the time of the great Maurya emperor Aśoka, who for the first time known to Indian history consolidated the greater part of India into an empire. These records are found inscribed on rocks and pillars and in caves which are distributed over an extensive area from the North-West Frontier to the Mysore State in the south. We learn from his rock edicts that in the western border of Aśoka's dominions there were several tribes who are named in these records as Yonas, Kambojas, Gandhāras, Raṭhikas, Bhojas and Pitinikas. The Yonas, or Yavanas in Sanskrit, could at this time be no other than the Greeks. In the 13th rock edict Aśoka definitely mentions five contemporary Greek princes, four of whom have been identified with certainty. They are Antiochus Theos (B.C. 261–246) king of Syria, Ptolemy II Philadelphos of Egypt (B.C. 285–247), Antigonus Gonatas of Macedonia (B.C. 276–239) and Magas of Cyrene (*circa* B.C. 300–250). The fifth ruler may be either Alexander of Corinth (*circa* B.C. 252–244) or Alexander of Epirus (*circa* B.C. 272–255). All these five, however, were Aśoka's neighbouring rulers. The Yonas referred to above as being mentioned along with other tribes were also Greeks but they lived within the empire of Aśoka, and perhaps formed a small principality in the North-Western Frontier. The Kambojas as a tribe are well known also from

Indian literature. Some scholars locate them in the Kabul Valley, while some others place them in a territory just south of Kashmir. The Gandhāras had their capital in Peshawar and this name is now well known to all students of Indian history and culture from the invaluable contribution they made towards the development of Indian art. Raṭhikas, about whom little is known from literature, may have belonged to the Maratha country, though some have preferred to place them in the Punjab territory. Little is known about the Bhojas and the Pitinikas. The other tribes mentioned in the edicts are the Andhras, the Parindas, and the Nābhakas and Nābhapaṅktis. Of these we know that the Andhras occupied the country between the Godavari and the Kistna for centuries while the precise habitat of the other three is still uncertain. In the south, Aśoka's borderers were the Cholas and the Pāṇḍyas, the two well-known dynasties in the Tamil country and the Satiyaputa and the Keralaputa, the country of the latter of which is certainly identical with the present-day Malabar. It will thus be seen, as has already been pointed out by Rapson, that 'the region occupied by the southern border peoples includes what is now known to ethnologists as the Central Belt, and still contains the largest groups of primitive tribes to be found in India'.

Associated with the Yavanas are the names Śakas and Pahlavas found in inscriptions of a later period. The Śakas are frequently mentioned in Indian literature though it elicits very little information about their origin and history. We, however, know from inscriptions that already in the first century B.C., the Śakas who were of the Scythian stock, were established in Sind and the Punjab. They had their subordinate rulers in the provinces and also local governors who were styled as Kshatrapas. There was another Śaka dynasty in Western India the rulers of which called themselves Kshaharātas in inscriptions and are commonly known as the Western Kshatrapas of Kathiawar and Malwa. The Pahlavas are no doubt to be identified with the Parthians who succeeded the Śakas in Siestan and Kandahar and in course of time extended their power in North-Western India. The next important ethnic tribe mentioned in inscriptions is the Kushāṇas. The most powerful ruler of this dynasty was Kanishka whose sway extended over the whole of North-Western India and perhaps as far as the Vindhyas in the south and who appears to have exercised a considerable influence even in eastern Turkestan. Scholars have tried to come to a conclusion about the ethnic stock of the Kushāṇas from the representation of their rulers on coins which have come down to us in very large numbers. It was nearly thirty years ago that Kennedy in an article in the *Journal of the Royal Asiatic Society* tried to prove the Turki origin of the Kushāṇas. According to the description given by him, Kanishka 'has the pointed cranium, the salient cheek-bones, the large, long and heavy nose, the

thick beard—and his coins represent him as a powerfully built barbarian king, clad in the loose coat and huge boots which were the common dress of Turkestan'. In showing the inconclusiveness of the arguments of Kennedy, Sten Konow has pointed out that the Turki element is rather late in the history and ethnology of Chinese Turkestan and the likenesses described by Kennedy are characteristic of the so-called *Homo alpinus* which is found in a large extent among the people of Chinese Turkestan. There can be no doubt, however, and here the inscriptions come to our aid, that the original home of the Kushāṇas was in Chinese Turkestan and that they were undoubtedly Iranians as several terms and designations used by the Kushāṇa rulers in their epigraphs would invariably indicate.

The Allahabad inscription of the great Gupta emperor Samudragupta who conquered the whole of Northern India in the fourth century A.D., mentions a number of autonomous tribes of India such as the Mālavas, Ārjunāyanas, Yaudheyas, Madrakas Ābhiras, Prārjunas, Sanakānīkas, Kākas and Kharaparikaras. It may be mentioned without going into details that some of these are known from other records and also from Indian literature and that at least a few of these are known to have been ethnic tribes.

The next ethnic tribe known widely from inscriptions and literature is the Hūṇas, the Huns of the Roman history and the Hiung-nu of the Chinese annals, the first invasion of which was driven back by Skandagupta, son of the Gupta ruler Kumāragupta, when the former was a crown prince. After the death of Skandagupta, however, these barbarians again swept the country till their power in India was broken altogether early in the sixth century A.D. at the time of the Hūṇa ruler Mihirakula. The Hūṇa domination in the Oxus Valley also did not long survive the death of Mihirakula where their power was gradually destroyed by the Persians and the Turks.

The list given above is by no means exhaustive but it gives us a fair idea of the kind of information we can expect from inscriptions. The later inscriptions contain the names of various other tribes which can be traced directly or indirectly to those found in India at present such as Nāgas, Kirātas, Śabaras, etc. and even includes the names of many present-day aboriginal tribes such as the Bhils, the Gonds and even the Todas of the Nilgiris.

The inscriptions also provide us with information which has some bearing on social anthropology. They give us, though mostly in later records, the traditional origin of the different ruling families whose genealogy they invariably contain. Although in most cases the origin is traced to an eponymous hero whose existence was invented when the genealogy of a particular dynasty was being framed and much of what we get is mythological, the accounts furnished often give us a fair idea of the origin of such families and sometimes of their

totems. In fact, the inscriptions give an account of the origin of most of the mediaeval dynasties—sometimes tracing their origin either to the Sun or the Moon and placing them in the list of one or other of the two great dynasties, the solar and the lunar, but at times they bring into evidence other factors in fixing their origin. This is particularly so in case of dynasties which seem to have risen from somewhat obscure origin and a few instances should be enough to prove my point. We may take for example the Chalukya dynasty which was a powerful dynasty ruling in the Deccan in the sixth century A.D. The progenitor of this family is stated to have sprung, as a saviour of the world, from the *Chuluka* or the hollow of the hand of Brahman, when Indra came and complained to him about the sinfulness of the world. Some time later two great heroes Hārīta and Mānavya were born in the family who raised it to great distinction and all the grants of the Chalukyas mention the family as Hāritiputra and belonging to the Mānavyagotra. The origin of the Kalachuryas is traced to one Kṛishṇa who was an incarnation of Śiva and who in the guise of a barber contrived to kill an evil-minded king at Kālañjara and became famous by acquiring possession of the Ḍāhala or Chedi country. The mythological origin of the Hoysaḷas or Poysaḷas who connect their family with Lord Kṛishṇa, is thus given in inscriptions. In the Yadu lineage there was a Saḷa who with a view to acquiring sovereignty worshipped the goddess Padmāvatī in company of a Jaina ascetic. A tiger sprang to obstruct the rites when the ascetic said 'poy Saḷa' which in Kanarese means 'kill, O Saḷa'. From the slaying of the tiger through which Saḷa obtained the boon of goddess, the family was known as Poysaḷa and the crest or banner of the family bore the representation of a tiger.

Turning to Central India and Rajputana we find the Paramāras tracing their descent from a hero born out of the sacrificial fire pit of the sage Vasishṭha on Mount Abu. This shows that mythology connects them with Agnikula and some scholars, both Indian and European, have interpreted the myth to mean that they were of foreign origin and possibly of the Hūṇa-Gūrjara stock.

In Orissa the progenitor of the Bhañjas is stated to have come out of the egg of a peahen and that of the Śailodbhava's was born of a block of stone. If these legends do not show anything else they show at least the totems of some of these dynasties, such as tiger, boar or the peahen.

Another interesting evidence which can be collected from inscriptions is the presence of foreign elements among the people of the country. Whatever may the Smṛitis or Dharmaśāstras say to the contrary, history shows that hoard after hoard of alien tribes came to India as invading forces but most of them remained to stay in the country, adopted the religious faith of the people of the land, got into matrimonial connections with them and

gradually merged in the population of the country. We know from inscriptions that not only did such foreigners embrace Buddhism and made gifts of Chaityas, monasteries and other religious benefactions, they, on most occasions, actually adopted Indian names which in course of time made one forget their alien origin. We have also evidence, though often indirect, to show that such people adopted the Brahmanical faith also. There is, however, at least one clear instance where a Greek is stated to have embraced Hinduism. A pillar inscription found at Besnagar in the Gwalior territory records that the pillar which was a *Garuḍadhvaja* was erected in honour of the god Vāsudeva by the Bhāgavata or Vaishṇava Heliodoros, son of Dion, who came to the court of the king Bhāgabhadra of the Śuṅga dynasty as an ambassador from the court of the Greek king Antialkiḍas. Similarly, we know that the successors of the Greeks, the Śaka rulers were mostly Buddhists. The epithets which they themselves bear and the symbols found on the coins struck by them areBuddhistic. The Kshatrapas, who ruled in the provinces as the governors of this dynasty and were themselves Śakas, were followers either of the Buddhist or of the Brahmanical faith. Thus while the Northern Kshatrapas, i.e. the family ruling at Mathura, were Buddhists, the Western Kshatrapas ruling over Surāshṭra and Mālwa followed the Brahmanical faith. Though most of the names borne by these rulers are Indian, there is clear indication in the names of earlier rulers, such as Chashṭana of the former and Nāhapāna of the latter family, that these families were of foreign origin. In fact, inscriptions themselves mention them as Śakas and at the same time produce evidence of their following an Indian religion. In a cave inscription at Nasik in the Bombay Province which records the dedication of a cave and cisterns by Ushavadāta son of Dinika and son-in-law of *Kshaharāta Kshatrapa* Nāhapāna, refers to the donor as one who had made various gifts of money and cows to gods and Brahmins in different places of pilgrimage and who had acquired merit not only by paying the expenses of marriages of Brahmins in holy places, apparently when visiting them, but in addition by feeding one hundred thousand Brahmins every year. Though the name in the present case is Indian, his connections definitely show that he was of foreign origin. At the same time the record shows that Ushavadāta was a follower of the Brahmanical religion and was apparently admitted to the folds of the Hindu society since the Brahmins and Brahmanical deities accepted gifts and food from him.

The rulers of the great imperial power in North India in the first century B.C. and the early years of the Christian era, viz. the Kushāṇas, were followers either of Buddhism or of Brahmanism. The legends and symbols on the coins of Kujula Kadphisis and his successor Wima-Kadphisis, two of the early rulers of this dynasty, show—and both these names are non-

Indian—that while the former was a follower of the Buddhistic faith, the latter was a Śaiva. The name of Kanishka, the successor of Wima is well known in Buddhist literature as a patron of Buddhism but his coins show also Hindu deities side by side with Greek and Iranian divinities. The coins of his successors show representations of Hindu deities which undoubtedly point to the faith they followed.

Though nothing definite is known about the origin of the Andhras—who are mentioned in the edicts of Aśoka and the Aitareya Brāhmaṇa where they are stated as living on the fringe of the Aryan civilization, and who rose to be a ruling power in the south in the second century A.D.—we know that they had matrimonial connections with the Śakas. It is stated in the Girnar inscription of the Western Kshatrapa Rudradāman that he twice defeated Śātakarṇi, the lord of the Deccan, but did not destroy him on account of their near relationship. We know from a record in the Kanheri caves that this Śātakarṇi was no other than the Andhra king Pulumāyi, who married a daughter of the Mahākshatrapa Rudradāman.

Another ruling family in the south, but of a later period, is the Ikshvākus. Very little of this family was known until a few years ago when a number of inscriptions of this dynasty were discovered at Nāgārjunikoṇḍa in the Guntur district of the Province of Madras. A study of these records would show that while the queens and princesses of the royal house were apparently devotees of the Lord Buddha, as the foundations of the religious monuments at the site were mostly due to their munificence, the rulers themselves were followers of the Brahmanical faith as they are stated to have performed Vedic sacrifices like Agnihotra, Agnishṭoma, Vājapeya and Aśvamedha, to have been protected by the Lord Mahāsena and to have given in charity crores of gold, hundred thousands of kine and thousands of ploughs of land. That there was no restriction for these rulers in marrying into families of foreign origin is shown by at least two incidental references in these records. One inscription mentions that one of the queens was from the royal house of Ujjayinī. We know that about this period the Western Kshatrapas had their capital at Ujjayinī and it is not unlikely that this queen came from this illustrious house of Mālwā. Another record of the same family states that the sister of the ruling king was married to the ruler of Vanavāsa and it is almost certain that the latter was a prince of the Kadamba dynasty which we know was of foreign origin. Incidently, inscriptions of these Ikshvāku rulers have given us some information which is interesting to an anthropologist. In the earlier inscriptions of one of the rulers Siri-Virapurisadata, a royal lady Chāntisiri by name, who was responsible for many donations in the Buddhist establishment at Nāgārjunikoṇḍa, is called the father's sister of the reigning king, while in the inscriptions of later years of the same ruler, she

refers to the king as her son-in-law. The practice of cross-cousin marriage is well known in the south and though references of marriage with mother's brother's daughter are found often in inscriptions, this is the earliest reference found in inscriptional records of the marriage with a paternal aunt's daughter which is not ordinarily allowed by the Smṛitis outside Southern India.

I shall now bring to your notice only another line of kings which ruled in Assam, the eastern frontier of India. There are four early dynasties in Assam, the ancient Prāgjyotisha, which trace their descent from Bhagadatta, son of the demon Naraka. These are: The Bhauma rulers of Hārūppeśvara, the Bhauma-Pālas of Durjayanagrī, the Pushyavarman family of Prāgjyotisha to which belonged the great ruler of Assam, Bhāskaravarman, mentioned by the Chinese traveller Yuan Chwang, and the Śālastambha family of Hārūppeśvara. The story of Naraka is well known from the Mahābhārata and the Kālikāpurāṇa which is a comparatively late work. According to the former, Bhagadatta fought in the Bhārata war on behalf of the Kauravas and was ultimately killed by Arjuna. In some of the inscriptions the rulers of the line of Śālastambha are definitely called Mlechchhas and though the kings of this line are differentiated from those of the line of Naraka, it may be proved indirectly that Naraka's successors were also not of indigenous origin. In the Sabhāparvan of the Mahābhārata it is stated that Bhagadatta attended the Rājasūya sacrifice of Yudhishṭhira with the Mlechchhas and we know that Naraka was made ruler of the country of Prāgjyotisha which was inhabited by the Kirātas. These evidences by themselves do not prove that Naraka and Bhagadatta were of Mlechchha extraction themselves. But another evidence is now forthcoming which would show that the rulers tracing their succession from these two mythological personages were of foreign origin. About a year ago an inscription was discovered in the Gilgit region an impression of which was very kindly sent to me for examination by Sir Aurel Stein. The inscription is of the time of the Paramabhaṭṭāraka Mahārājādhirāja Parameśvara Paṭoladeva Shāhi Śrī-Nava-Surendrāditya Nandideva. The inscription is dated in the 47th year, perhaps of the Laukika era which was in vogue in that part of the country. As the century is omitted in this particular era it is not possible to determine the age of the record definitely but palaeographically it has to be referred to a period between the seventh and the ninth century A.D. This ruler is again mentioned in the colophon of a Buddhist manuscript which was discovered by the Kashmir Archaeological Department in 1938 in the course of excavations of certain mounds at Gilgit, but here he has the epithet Shāhānushāhi. Another ruler of the same dynasty is known from the colophon of a manuscript of *Bhaishajyaguru* which was also found in the same place in 1931. Dr. Dutt of the Calcutta University, who

has edited the last-named manuscript, reads the name as Sāhi-Surendra-Vikramāditya-Nanda. There is little doubt that both these rulers were connected with the Shāhi rulers mentioned in the Rājataraṅginī of Kalhaṇa, the Kashmirian poet and historian and also in a few inscriptions from the Punjab. A few of these rulers are also mentioned by Bīrūnī. This dynasty had its capital in Ohind and Sir Aurel has shown that though the rulers of this family are described as Hindus, they really belonged to the Kushāṇa stock and therefore were of foreign origin. The interest of the Gilgit inscription lies in the fact that the ruler mentions himself as being born 'in the lineage of Bhagaddatta'. There is no evidence to show that the Assam rulers were in any way connected with the Gilgit rulers but perhaps it is significant that the ruling families in two frontiers, one of which is definitely known to be of foreign extraction, should have traced their descent from a common mythological ancestor. These few instances will show the importance of epigraphical records in the study of problems connected with ethnology. There are many other points connected with ethnology on which the inscriptions can throw light, such as the study of the origin and development of castes, of the *gotras*, of the matrimonial problems and their bearing on the society and on which much valuable work has already been done by scholars. No doubt this study has to be supplemented by a reference to literature and archaeological evidences other than epigraphy but the part played by inscriptions in this study is of great value and the information supplied by them cannot be ignored for the purpose of research. Though much has been done, much yet remains to be done and it is hoped that the value of inscriptions in the study of these problems will not be lost sight of by future scholars.

SECTION OF MEDICAL AND VETERINARY SCIENCES

President:—F. C. MINETT, D.Sc., M.R.C.V.S.

Presidential Address

(*Delivered on Jan. 4, 1943*)

INFLUENCE OF CLIMATE ON THE INCIDENCE OF DISEASE

It is my pleasant duty in the first place to express my thanks to those responsible for electing me to the presidential chair on this occasion. The value of a gathering such as this has been rightly recognized. The Indian Science Congress, as in the case of the British Association for the Advancement of Science, is a medium whereby the various scientists may meet and discuss their problems in common. Unfortunately, in a large country like India distance forbids frequent meetings and this lack of intercourse must be felt by many, especially by those who have to spend their time in more remote places. Joint discussions such as these have become the order of the day, and rightly so, for is it not true that ideas are often stimulated much more readily during personal contacts than by the perusal of cold print? Now with regard to our own Medical and Veterinary Section, I would like to stress the immense value to both professions of constant associative and comparative effort along our individual yet constantly converging lines of research. In Great Britain, which I left three years ago, we have medical and veterinary men holding joint discussions, e.g. in the Section of Comparative Medicine of the Royal Society of Medicine. We find veterinary men working in medical institutions and producing better work in consequence; we find medical men giving attention to diseases which may be primarily those of animals. We know that the same sort of thing happens in other European countries and in the United States. If a liaison of this sort can be achieved, with proper safeguards so that the weaker partner is in no way subjugated, it will be of immense benefit to science.

There are many examples which could be given illustrating the interdependence of medical and veterinary science. So far, it must be acknowledged, veterinary science has gained more than it has given by contact with the stronger partner. Lengthy discussions which have appeared in the medical press during recent years in Great Britain on the improvements that are required in the medical curriculum have found an echo in

veterinary councils and it is quite obvious that the problems involved are fundamentally similar. As one who has had the task of teaching pathology to veterinary students, I can fully realize the deficiencies in our knowledge of the special pathology of domesticated animals and in consequence how many were the illustrations which had to be borrowed from human pathology in which domain we were, quite obviously, not at home. The same dependence on medical knowledge has been felt even more keenly by teachers of the physiology of domesticated animals.

From the opposite angle one has to remember the enormous extent to which medical science has had to rely upon experimentation on animals. Examples of this, no doubt, readily come to your minds, such as the revelation of the paths by which bacteria invade the tissues once they have gained entrance to the body and the whole mass of knowledge that is embraced by the subject of pharmacology. How numerous indeed are the cases where medical and veterinary collaboration can be useful in the elucidation and prevention of disease in man and animals. As a recent and illuminating instance of this, I call to mind a village in Hyderabad-Deccan where I was shown standing side by side children and cattle, both presenting clinical signs of what had been proved to be fluorosis.

In considering one's own immediate interests, one must, of course, avoid being too parochial. We shall remember that all sciences are interlinked and that many have common boundaries. How frequently it happens that the research worker who is not labouring in a very narrow field finds himself involved and probably totally submerged in problems which more properly belong to another sphere! Here then accrues the enormous advantage of having workers in kindred sciences labouring side by side within the same institution. In making this point I need not go beyond my present experience. At the Izatnagar branch of the Imperial Veterinary Research Institute we have pathologists, bacteriologists, chemists, veterinary zoologists, such as helminthologists and entomologists, specialists in the nutrition and husbandry of domesticated animals and of poultry, working side by side and soon we hope to add students of animal genetics. Upon the Director falls the sometimes difficult task of trying to persuade his fellows that the atmosphere of the water-tight compartment is likely to prove rather stifling to the imagination.

Coming back to our own immediate sphere, I would cite as another example of the assistance which veterinary science may derive from medicine, the work which is my own particular interest in India, work which falls within the epidemiological or epizootiological field. This has to do with the effect of climate and weather conditions on animal health and on disease, a subject which has attracted many workers on the medical side and on which with your indulgence I wish to expand for a few

moments. As Sir L. Rogers (1925) said, 'The extreme variations in rainfall, temperature and humidity in different parts of India make it especially suitable for studying the influence of climate on disease incidence'. We know how important is the influence of air temperature and humidity on the spread of such diseases as filariasis, malaria and human plague (Basu and Sundar Rao, 1939; Basu and Knowles, 1942; White, 1918-19). This fact in one respect at any rate is a fairly simple one and is explained by the well-known influence exerted by atmospheric temperature and humidity on the life processes of many insects.

The direct influence of such climatic factors on the warm-blooded animal in its reaction to living parasites, such as bacteria, is possibly more difficult to investigate, even when external conditions are fairly constant, in spite of the fact that the problem involves the interaction of two biological agents instead of three. It becomes a still more difficult puzzle when external conditions vary, as for instance when the animal liable to attack is accustomed to dry heat and is then exposed rather suddenly to moist and cooler surroundings. Yet these are matters that must be explored if we are to understand fully such matters as disease epidemics in man and animals, the varying incidence of carriers, the germination *in vivo* of latent spores, or if we wish to fathom those problems of acclimatization which are so important economically with domestic animals in the more extreme climates. Climate again may be only one of the environmental factors at work and by no means the most important; other complex and often interacting influences are frequently still more important, such as, the naturally acquired immunity of the population, conditions of crowding with all its immunological implications, animal movement or human migration (Greenwood *et al.*, 1936). Again, the outstanding influence may be largely or purely a genetical one (*cf.* Webster, 1924; Pritchett, 1925; Hill, 1934); it may be nutritional as when nutritive conditions of animals are indifferent, e.g. in the important matter of their vitamin A supply. Then again, normal variations in incidence which are undoubtedly seasonal in nature or coincidental with season may be quite altered by other and more potent factors, e.g. by crowding animals together at a time when the normal incidence is low, or as in the case of foot-and-mouth disease in tropical countries where in individual herds the disease tends to be most prevalent every 3 to 5 years, the lowered incidence in intervening years being due to specific immunity acquired during the previous outbreak. Or conversely, as has been shown with cholera (Lal *et al.*, 1941), the advent of improved facilities for dissemination may raise the incidence of the disease in some areas but not in others, owing to neutralizing climatic factors. Nor finally must we lose sight of the fact that environmental influences—which, as Stallybrass (1928) has emphasized, are always secondary in nature—may work not upon the host but upon the parasite;

in the case of climatic factors, for example, the effect may be exerted on the viability of the parasite outside the body (*cf.* Rogers, 1925-26; Russell, 1925-26), climatic conditions may govern its transportation from one animal to another, and, by hypothesis at any rate, its multiplication in the outer world. Again, it has been occasionally noted that bacterial variants of greater virulence (killing power), e.g. with streptococci, pneumococci, seem to make their appearance during the colder season (*cf.* Gaskell, 1927).

C. A. Mills, in his thought-provoking book 'Medical Climatology', remarks that the relation between weather effects and disease in man cannot always be evaluated by statistics, owing to the number of complicating factors. Experimentation on animals then becomes necessary with results, which may or may not confirm previous deductions. Mills further remarks that no analysis of the effects of weather factors under controlled laboratory conditions has yet been made.

The practical value of understanding all these things is that it enables us to explain not only how epidemic disease arises but also in some instances to forecast the appearance of epidemics, to throw light on complaints the causation of which is not fully elucidated, for instance rheumatic fever, arterio-sclerosis, summer diarrhoea in infants, or to obtain a clue as to the natural method of transmission of diseases of which the cause but little more is known, e.g. horse sickness, encephalomyelitis in equines. Moreover, it by no means always follows that there is no way of alleviating the effects of adverse climate; in this respect rich men and sometimes even domesticated animals are more fortunate than poor men. Finally, even when one has reached an understanding of what influences are at work, there still remains the often more difficult task of understanding *how* they work.

This is not the place or time to try to go deeply into the work which has been done on the subject of climate as an environmental factor. Some of it has become fairly common knowledge, and it has been acquired, as is usually the case, by scientific observation and by experiments on man or animals.

While, speaking generally, a good deal is known of the effect of environmental factors, including climate, on human beings and small experimental animals, comparatively little information is available in respect of the domesticated animals, in India at any rate, and much of what does appear to be known is not well documented. Too often, the available knowledge consists of vague generalizations, mostly resting on insecure evidence. This is not altogether the fault of the professional man, since it is notoriously difficult, especially in the case of low-valued animals like sheep and goats, to obtain authentic data for animals. However, a veterinarian coming out to this country will be at once struck by the prevalence of many animal diseases during the monsoon period. The same has also been noted in

other parts of the subtropics. In the hope of obtaining more exact information we are now collecting through provincial Directors of Veterinary Services disease incidence figures over a period of years just as has been done on the medical side with cholera, typhoid, etc. What success we shall have remains to be seen. We anticipate we may be able to sketch a picture which will be true in its broad outlines but the knowledge that even medical statistics in India are not always highly reliable does not encourage the expectation that our detailed conclusions or assumptions may be accurate. In this work I am not referring to helminthic diseases, such as the prevalent fascioliasis of cattle in India or of tick-borne diseases, such as piroplasmosis or theileriasis, where particular conditions favour the life of the intermediate host, but to certain diseases, such as anthrax, blackquarter and rinderpest, where the effect may be on the host or the parasite or both. In the case of anthrax and blackquarter, which are often spoken of as soil diseases, my colleague M. R. Dhanda and I (1941) have brought evidence to show that these organisms do not multiply in the outer world. This was a simple question to which no precise answer had hitherto been given.

As to the monsoon prevalence of disease, it does appear to be a fact that wet conditions are a sore trial to many animals in some tropical countries, even in certain circumstances to water-loving animals, such as buffaloes, since it is the younger animals of this genus which are specially prone at monsoon times to haemorrhagic septicaemia—a disease caused by a pasteurella. Rainfall must, it seems, have a preponderating influence on animals—an influence far more severe and abrupt than cold moist air—and this point we are trying to unravel by the use under a variety of conditions of artificial showers. I wish to lay emphasis, as Mills has done, on this experimental approach to the problems. Already we think we have established that sheep inoculated intramuscularly with very small doses of spores of *Cl. chauvoei*, the causal agent in cattle and sheep of the disease known as blackquarter, show clinical signs of the disease and die after being exposed under certain conditions to a shower, whereas control sheep not so wetted remain healthy. Presumably, this result depends in some way upon lowering of the body temperature, while from the opposite point of view we find that guinea-pigs injected intramuscularly with a suitable number of the spores and then heated by being placed for a time in an incubator at 40°C. are more likely to escape clinical infection than controls kept at laboratory temperature. This, we may suppose, is a phagocytic effect. An analogous finding has previously been reported in the case of anthrax; and indeed, it is now well known that an artificially-induced fever can alter the course of certain infections, so that the method has come into prominence in therapeutics. We have to distinguish here between short and transient overheating and more prolonged

and moderate heating, since the latter under certain conditions may reduce the resistance of small experimental animals to bacterial infections (McDowell, 1923; Kligler and Olitzki, 1931). Animals which escape infection after brief overheating continue to carry living spores in the muscles for days or weeks. What exactly is the practical importance of the observations mentioned we do not know at present, but the facts are suggestive. If we can get to know the precise circumstances in which showers of rain exert a baneful effect, we may be in a position to give well-authenticated advice to stock-owners. There is already some information on the point. From experiments carried out by French (1938) in Tanganyika it seems that the adverse effects on the animal constitution in the early part of the rainy season are not solely due to fall in body temperature resulting from the rain but are in large part nutritional. The first effect of the rain is to soak the old fibrous herbage remaining at the end of the hot dry season, which is thus rendered still more unpalatable and the fall in live weight which has been continuous during the dry season is in consequence accentuated during the first rains before green grass appears. When the grass begins to grow, the animals readily eat it, but unfortunately the immediate effect is digestive disturbance accompanied by diarrhoea, and this in some anaemic and poorly nourished animals is the last straw and they succumb before they have got used to the new diet. In two areas of India a similar state of affairs has come to my notice.

Another problem with which we are concerned is that of the deterioration or degeneration of cattle, and this, it is hoped, to investigate through the medium of the Imperial Council of Agricultural Research. It is a well-known fact that animals which do reasonably well in drier areas do not in general thrive well when they are transferred to more moist conditions, and examples in illustration of this fact could be given for animals in India. We do not yet know whether this deterioration is solely or mainly due to climate but, should it prove to be so, we shall have to determine whether climate is exerting a direct effect on the animal physiology or whether the effect is indirect and more properly to be ascribed to nutritional or parasitic causes. In poultry we know that certain breeds are less resistant than others to the effects of a hot atmosphere. The remedy may lie in part in the realm of genetics, a matter which is under investigation by the Poultry Research Section at Izatnagar. Speaking of poultry brings to mind the question of egg size. The Indian egg is notoriously small. Whether in the course of its evolution it is tending to get smaller or larger I do not know, but from my perambulations of India, I cannot avoid the disturbing thought that it is becoming still more diminutive! Egg size again may be a matter of seasonal variation so that if we can develop fine poultry types which are relatively resistant to hot atmospheres, we shall be serving a useful purpose.

I wish in conclusion to make some reference to the control of disease. In this matter it always seems to me to be wholesome to adopt the attitude that things are wrong because somebody is doing the wrong thing. I will give a few examples to show my meaning. In India the means for disposal of animals' carcasses is too often such that they become a menace to the living; again, farm animals may be allowed to become chilled by exposure to heavy rain; cultivators' animals may be permitted to congregate in large numbers for purposes of commerce without adequate precaution against the spread of infectious disease; mosquitoes may be allowed to breed unhindered, while in the same connection human carriers of malaria may be permitted to wander at large without steps being taken to prevent mosquitoes biting them; lastly, the common rules of sanitation may not be observed by those unfortunate people who carry the germs of cholera or typhoid. Admittedly, it may be difficult at times to avoid doing the wrong thing, or we may be only vaguely aware that we are making some error; or the fact that a wrong is being done at all may only be demonstrable by investigation. In cancer, for instance, we have some rather vague knowledge that the body or some part of it has for long been subjected to some irritation or undesirable stimulus. Or again, the domestic cook may unwittingly play the part of the bacteriologist in storing to-morrow's soup or the milk for to-morrow's custard in a warm place and so bring about an outbreak of food-poisoning of the toxin type. Evidently, there are all degrees of folly to combat, although a few cases can be mentioned where no ordinary common sense can be relied upon to stop the dissemination of disease germs. This is so in the case of foot-and-mouth disease which has been described as the most infectious disease known.

In India, it must be said that there are special difficulties in disease control work and it is unfortunate that progress must inevitably be slower than in some other countries. One has only to think of the prevailing religious prejudices, which permit the survival of useless animals and active disseminators of disease, of the large numbers of carrion feeders, such as crows, vultures, jackals, of the prevalence of insect and similar vectors. Added to these, is the undeveloped legislation for controlling animal disease and the extensive movements of cattle, sheep and goats which are made annually in the search for food or to avoid the heavy monsoon weather. In the medical field, too, there are hindrances to progress due to the habits of the lower social orders.

But I think we may say of our work in India that, in spite of shortage of staff and difficulties of communication, much success has been achieved both in the laboratory and in the field and I would pay a tribute to those whose duty it is, under somewhat adverse conditions, to promote the health of man and animal.

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SECTION OF AGRICULTURAL SCIENCES

President:—RAO BAHADUR Y. RAMCHANDRA RAO, M.A., F.R.E.S., F.A.Sc.

Presidential Address

(Delivered on Jan. 3, 1943)

THE NEED OF PLANNING ON AN ALL-INDIA BASIS IN CERTAIN ASPECTS OF AGRICULTURAL ENTOMOLOGY

I wish, first of all, to take this opportunity of thanking you for the great honour, you have conferred on me, of presiding over the section of Agricultural Sciences—a privilege enjoyed by many distinguished scientists in the past. In view of my lack of the right type of qualifications, I am rather afraid that I shall suffer by comparison. Although I would yield to none in my esteem of the aim and ideals of agricultural workers, and although I have always considered it a great privilege to work in the Agricultural Department and to be in a position to be of some help to the Indian cultivator, I am conscious of the want of an all-round knowledge of various natural sciences, which have been utilized in the building up of modern agriculture, and I feel, therefore, rather diffident about my ability to fulfil my functions. I wish, therefore, to crave your kind indulgence in the matter, and would request you by overlooking my shortcomings to help me to carry on my duties.

In the above circumstances, it would be too presumptuous on my part to seek to follow the footsteps of some of my predecessors by devoting my address to an up-to-date review of agricultural progress or endeavour to offer advice on agricultural problems or on methods of agricultural research. With your permission, I would like to confine myself to a topic connected with my life-work, and I hope I shall be pardoned if my theme should happen to deal with certain entomological aspects of agricultural research.

The toll levied by insect pests on cultivated crops is, as well known, often sufficient to offset the improvements in yield and quality effected by the agriculturist by having recourse to better seed, better manure and better cultural methods; and the work of the economic entomologist in studying the pests and diseases

of crops and devising remedial or preventive measures for combating them effectively and economically is no mean task. Indeed, my illustrious predecessor, Dr. T. V. Ramakrishna Ayyar, has in his address of 1939 at Lahore most exhaustively dealt with the rôle of the entomologist in Indian agriculture, and there is little more that can be said on the subject.

Need of a central agency to deal with pests of migrating habits

What I propose to talk at the present meeting is about the desirability of planning out detailed studies of some of the major insect pests of India that have the power of spreading from one part of the country to another. In the case of such pests as are known to appear year by year on crops at particular times and at particular places, provincial entomologists should be well able to study them in detail and devise appropriate methods of dealing with them. There are, on the other hand, other insects possessed of a considerable degree of mobility, as for instance, locusts. The swarms of the Desert Locust, for example, appearing in the monsoon months in the Punjab, the United Provinces and Rajputana, are known to be derived from the spring breeding areas in Baluchistan, Iran and Arabia, and similarly, it has been found that locusts, bred in Rajputana and the Punjab during the monsoon period, may fly in autumn as far east as the confines of Assam, or may reach as far south as the northern districts of Madras. Evidently, in such a case, a provincial entomologist would be handicapped greatly, if he is asked to devise control measures against an insect which had had its origin in a distant province. Clearly, in such cases, an all-India agency is necessary to collect information on the movements of the pest from all likely breeding places and circulate a warning to the provinces likely to be affected. Happily, such an agency has been functioning in India during the last three years so far as the desert locust is concerned. There are, besides, two other locusts in India also likely to invade the various provinces of India when conditions are favourable, viz. the Bombay Locust and the Migratory Locust. Unfortunately, sufficient information is not available on the breeding grounds or the areas of distribution and migration of these locusts, nor is there any definite knowledge as to the factors that may cause these insects to assume the swarming condition. I shall be dealing with these locusts in greater detail at a later stage.

Besides locusts, there are other insects which exhibit the propensity of appearing all of a sudden in enormous numbers under favourable circumstances. There is, for instance, the Paddy Armyworm, *Spodoptera mauritia* Bois., which is common in various parts of India, especially in Malabar, appearing in

huge numbers on young paddy and causing enormous damage. This pest appears so suddenly, finishes its work of destruction so swiftly, and, moreover, disappears so speedily from the scene of its activities, that there is hardly any time for taking remedial measures, unless an organization is kept ready in the immediate neighbourhood to deal with it promptly. In many of the cases investigated, there were definite indications that the infestation had come into existence by the appearance of flights of the parent moths from some distant place, followed by the laying of masses of eggs on the young crop. It was also always noticed that within a fortnight of pupation, few live pupae were to be seen in the soil. On emergence from the soil, the moths would appear to have flown away to some other place. Usually a second generation of the pest is not observable in the same locality, and very often the same place is never re-infested in the succeeding year. Doubtless, a migration of moths does occur, and this is to a certain extent confirmed by the fact that an attack on crops on the plains alternates with an infestation of hill-grasses at different seasons in the year. In Rhodesia, where an allied moth—*Laphygma exempta*—swarms on cereal crops, observations made have shown that moths may make flights exceeding a hundred miles in range. As such flights may be helped by the agency of winds, especially of those connected with cyclones or similar disturbances, there is a likelihood of a transfer of such infestations between neighbouring provinces. Besides *Spodoptera*, there are allied moths also capable of bringing about caterpillar swarms, such as *Prodenia litura* Fb., *Leucania unipuncta* Haw., and *Laphygma exigua* Hb., which have presumably similar habits of migration.

In Bihar, the cutworm—*Agrotis ypsilon* Rott.—is a serious problem for autumn crops. It appears in numbers from August onwards, but is not to be found in the plains between April and August. It is surmised that it migrates to the hills in spring and summer and returns to the plains in autumn. Similarly, the cabbage white—*Pieris brassicae* Linn.—is another instance of periodical migration, as it breeds on the plains of Northern India only during winter and spring, and disappears in April, probably migrating to the hills for breeding in summer. In these cases too, where the pests, on account of their powers of migration, are capable of spreading from one province to another, it would be advantageous if they can be studied by a central agency which can have access to all the affected tracts, so that the problem could be examined as a whole and the mutual influence of breeding in the different areas could be exactly determined.

The Deccan grasshopper—*Colemania sphenarioides* Bol.—is a problem by itself. Although it is not migratory in the sense that locusts are, it is capable of slow migration and of spreading from place to place. Its distribution, moreover, is such

that contiguous areas in four different political territories are affected. In *Bombay Presidency,* a large tract stretching from Ahmadnagar down to Dharwar is affected, while in the *Hyderabad State* districts adjoining Bombay are liable to infestation; in the *Madras area,* the districts of Bellary and Kurnool are infested, and in the *Mysore State,* the districts of Chitaldrug and Shimoga. In this vast area, the grasshopper usually appears in a serious form for a period of three or four years and then subsides again to reappear after a few years. Although it has been studied independently in these different areas by their appropriate agricultural staff, the workers in these areas do not, as a rule, know what is happening in the adjoining provinces, nor is there any system of communication of intelligence between adjacent States as to an outbreak of this pest, as is in general practice in provinces subject to locust depredations in North India. As the Deccan grasshopper is a pest which is responsible for a huge aggregate amount of damage to essential food-crops such as Sorghum and other millets,—a loss all the more serious as the whole area affected is subject to frequent visitations of famine,—it is desirable that it should be studied with a wider perspective than is possible under the present system. In the present state of our knowledge, there is only a vague indication of periodicity in its outbreaks, but nothing is known as to its original home, nor is there much information as to the factors contributing to its multiplication and spread. Its reactions to seasonal conditions have not yet been properly investigated. It is only when the researches are taken over by a central agency, and all available information collected by the different political units is examined in correlation with meteorological data and a proper ecological study of the insect is made, that reliable conclusions as to the full range of the insect's capabilities can be reached, leading possibly to radical methods of control based on fuller knowledge gained.

There are, besides, various other grasshopper pests which have a wide distribution in India and often cause serious damage to crops. The rice grasshoppers—*Hieroglyphus banian* Fb. and *H. oryzivorus* Bol.—are some of them, and *Aeolopus affinis* Bol., causing much damage to millets, is another. It would be useful if all the data recorded in the files of various provincial entomologists during the last three or four decades, or contained in season and crop reports of past years in the provinces, could be examined critically by a central agency and the results published for general information.

Some centralized schemes already in operation

In the course of the last two decades, various committees supported by a cess on exported produce have been constituted in India on an all-India basis for research work on various crops,

such as cotton, jute, lac, sugar-cane, etc., and in this connection problems relating to important pests affecting these crops have been under investigation as separate schemes. In this manner, a great deal of advance of knowledge has been effected on insects like the Pink Bollworm, the Spotted Bollworms, the Cotton Stem-weevil, and various pests of lac and jute. Schemes on the investigation on the various cane-borers have similarly been financed by the Imperial Council of Agricultural Research, as also researches on the Rusts of Wheat, the Cane Mosaic, and the Tobacco Virus.

Of the three locusts of India, the desert locust attracted the emergent attention of the Government of India in view of the serious damage done to crops during the years 1929 and 1930, as a result thereof a detailed scheme of locust research was inaugurated in December, 1930 under the auspices of the Imperial Council of Agricultural Research, which was in operation till the 31st March, 1939, and with which I had the honour of being associated. The results of these investigations were published partly as a series of articles in the *Indian Journal of Agricultural Research* by Khan Bahadur Afzal Husain and his collaborators (1933 to 1940) and partly by myself and others in the same journal (1933 to 1939). A detailed monograph on the ecology and distribution of the locust in its breeding grounds in India has already been submitted for publication (June, 1941), but owing to the exigencies of the present war conditions, it has not yet been taken up by the press. In the course of the locust investigations, a great mass of data on the movements and activities of locusts during the past locust outbreaks dating from 1810 was accumulated for study in correlation with meteorological data, but this work could not be undertaken by me on the completion of the report on the field investigations, as had originally been contemplated, for want of funds. If this work had been completed by now, it might have been of much use to the Locust Warning Organization of the Government of India, which is now busy with the control and study of the present locust outbreak, which commenced in 1940. All the accumulated locust data, however, have already been chronologically arranged and printed for reference by interested entomologists. It is to be hoped that the study of the old records would be taken up early by the authorities concerned.

Except for certain notes by Cotes in the *Indian Museum Notes* (Old Series), there is not much published information available in regard to the activities of the migratory locust in India, nor in the case of the Bombay locust except for Lefroy's account of the investigations made in 1903-04. In the course of the collection of old records on the past cycles of the desert locust, I gathered a fair amount of information on the occurrence of swarms of the Bombay locust in the Bombay Presidency from the Season and Crop Reports of the *Bombay Gazette* from

1874 to 1930. Through the kind courtesy of the Madras Government (Development Department), I was also able to extract much information from some of the printed Proceedings of the Board of Revenue for the years 1877–1886 regarding the flights of the migratory locust in Madras in 1878, and also on the movements of *Patanga* in Madras in 1877–1886. Since retirement from service, I have been able to examine further records in the Madras Records Office with the permission of the Madras Government. Recently, in 1942, I was also able to peruse, through the kind courtesy of the Chief Secretary to Mysore Government, the old volumes of the *Mysore Gazette* for the years 1877 to 1885 and collect much information in regard to the extension of the locust invasion of 1878 into the Mysore area. I now propose to set forth briefly some of the data obtained on the movements of these two locusts in the past in India, and also make some suggestions as to future work.

Limitations of our present knowledge of the Bombay Locust—*Patanga succincta* L.—in India

Published literature on the infestations of the Bombay locust in India is limited to (1) Cotes' articles on the 'Locusts of Bengal, Assam, Madras and Bombay' (Cotes, 1891), and (2) Lefroy's Memoir on 'The Bombay Locust—A report on the investigations of 1903-04' (Lefroy, 1906). As to its distribution, it occurs, according to Fletcher (1920), 'throughout the plains of India and Ceylon'. It is also known to occur in the Laccadive Islands as a pest of coconut both in the hopper and the adult stage. Outside the Indo-Ceylon region, it is known to be found in China, Sumatra, Java and Borneo according to Kirby (1914) and according to Uvarov (1928), its distribution extends to southern and south-east Asia and the Malay Archipelago. Uvarov has recorded outbreaks of *Patanga* in the Trengganu State in Malay Peninsula in 1930, 1931 and 1932 in October-December (Uvarov, 1933), and in North Borneo in 1933, 1934, 1936 and 1937 between August and February (Uvarov, 1937, 1939).

According to Lefroy, the main breeding areas of the locust are situated in the forest areas of the Western Ghats. It is only when it increases in numbers that it moves out of the Ghats to the northern parts of the Bombay Presidency (Gujarat, Khandesh, Ahmadnagar, etc.), and thence into Central India and the Central Provinces. In 1903-04, it is known that breeding occurred in Berar and the western districts of the Central Provinces, though nothing is known as to whether such breeding is normal in these areas. Cotes (1891) mentions the occurrence of swarms in Western Bengal and Bihar during the following years: Monghyr, 1862 and 1877; Patna, 1877; Manbhum, 1865 and 1881;

Burdwan, 1873; Santal Parganas, 1878; Durbhanga (Bihar), 1865. These swarms could not have been the desert locust, as it was not active in these particular years. In one case, a swarm appearing on 1st July, 1877 at Patna was found to belong to *Acridium succinctum* (or a closely allied species) by Saussure from specimens collected. Again in the case of a swarm that appeared in Manbhum district in June, 1881, 'the heads and wings' were said to have been of 'a red colour', an evident indication of the Bombay locust. It is not unlikely that all the rest of the swarms reported in Western Bengal and Bihar may have been *Patanga*. During locust surveys, stray solitary specimens of the Bombay locust have been found in the Rajputana desert areas, mainly in the autumn and winter months (Rao and Bhatia, 1939). Stray specimens have also been collected in the past at Pusa (Bihar) (August, 1917), Nilgiris (November, 1907), Coimbatore and other places.

Life-history and habits.—This locust has apparently only one generation in the year. The young adults appear about September, and they remain sexually immature for nearly 10 months, till the advent of the monsoon rains in June. Pairing then occurs and eggs are laid during July-August after good rainfall. According to Lefroy, only one egg-mass is laid,—a point on which confirmation is needed. The eggs hatch in 6 to 8 weeks according to the prevailing temperature. The hoppers go through 7 to 8 moults and take 8 to 10 weeks to reach the adult stage. The hoppers are *not gregarious*, but remain scattered among crops or grasses. According to Lefroy, they require a high degree of atmospheric humidity for their development, and failure of rains during the hopper stage is considered by him to be one of the main causes of the decline of an outbreak. The adults of the new generation usually collect into swarms during September-October, and begin to migrate in the general direction of the prevalent north-easterly winds. During cold weather, they remain in forest areas among hills and are relatively inactive. By February-March, they resume their flying activity, and during April-May, flights are noticeable in the northern parts of Bombay, in Central Provinces, in Hyderabad and Madras Deccan. By middle of June, as the monsoon rains begin, they begin to scatter seeking the open grass lands, where they pair and lay eggs. Soft clays are preferred for oviposition, and eggs are laid either among the grasses or in cultivated areas.

Migrations of this locust.—There is no information on record as to the direction or extent of migration except for the years 1883-84 (Cotes, 1891) and for 1903-04 (Lefroy, 1906). An examination of the data on the prevalence of locusts recorded in the season and crop reports of the *Bombay Gazette* for the years 1873 to 1931 has provided much information on the incidence of the locust in the Bombay area during this period. An analysis

of data collected from this source, as well as from others, such as the district gazetteers, has shown that this locust, like the desert locust, has been appearing in large swarms during a series of years, and disappearing thereafter for some years, only to re-appear again. Before 1873, the information is very scrappy. Buchanan (1807) recorded swarms of this locust at Mandya in Mysore in June, 1800. Swarms appeared at Poona in 1835, and in Panchmahals in 1845. There were flights in Belgaum in 1864 and 1865, and in Nandigama in Kistna district (Madras) in 1865. During the years 1873–75, swarms appear to have been active in Belgaum, Poona and Khandesh. As a result of the great drought of 1875, there were no flights in 1876-77, till late in 1877. Since then, swarms were noticeable in the province till 1885, in which year they disappeared. 1881–1884 was a period of great activity, and a great deal of damage was done to crops. There was a long break in the infestation from 1885 to 1897. Swarms re-appeared in 1898, and thenceforward they were continuously prevalent till 1908, except for 1899-1900 when there was a break due to drought. The infestation reached a climax in 1903-04 and declined thereafter. Since 1910, no large outbreak has occurred, only stray swarms having been recorded during this period during the years 1910-11, 1915, 1920 and 1925–27.

The data gathered from the season reports generally support the conclusions reached by Lefroy as to the *direction of migrations* in 1903-04. During the winter months, the swarms are usually found in the southern parts of the province. From March onwards, they become active, and from the middle of April the migrations begin. The south-west winds, which prevail in May-June, take the flights north and north-east into (1) Gujarat, Nasik or Khandesh, or (2) through Bijapur, Sholapur and Ahmadnagar, into Hyderabad State and thence into Berar and Central Provinces, or (3) from Dharwar into Bellary and Kurnool, and thence into Hyderabad State. Data collected from Madras and Mysore records indicate that some flights may pass into Mysore, thence into Anantapur and Cuddappa and ultimately into Guntur and Kistna districts. It is probable that these swarms cease migration and settle down for breeding wherever they meet with good rains. In 1904, flights that reached the Central Provinces in June are reported to have bred in the western parts of the province. Lefroy (1906), however, supposed that at this period 'many swarms came back to the Ghat region after they had moved out into the hot dry Deccan; leaving Sholapur, Bijapur, Belgaum and Ahmadnagar clear, these settled in the Ghats and remained there'. This is not supported by the reported swarm movements of this period. There is no sign of any return flights to the Ghats till October-November. It is more likely that swarms are carried further and further east or north-east by the S.W. winds and that those

that do not reach favourable rain-belts perish altogether. It is possible that some of them reach the hill areas of the Eastern Ghats in North Madras, or Orissa or the hill ranges of Central Provinces and Chota Nagpur and breed there during the rains. The swarms in Western Bengal mentioned by Cotes might have originated from some of these hill areas. When the breeding is over by September-October, the new swarms begin to fly, and in the northern areas of Bombay they are carried south or south-west by the north-east winds from Gujarat and Central Provinces. From the Madras records, it is seen that in certain years, for instance in 1877, 1878 and 1885, swarm flights from Dharwar side may take place in October-November towards Bellary, Kurnool, Guntur and Kistna districts. Usually, however, flights of the Bombay locust do not reach the Madras Deccan after June. There is no information about the direction of after-monsoon flights in Bengal and Bihar.

The phases of the locust: its outbreak-centres.—A biometrical examination of collections of the Bombay locust has shown that specimens collected from swarms are distinct from the isolated individuals collected during surveys in the years 1932–38 in the Rajputana desert, and there is little doubt that they represent respectively the *gregaria* and the *solitaria* phases of the species. A detailed biometrical examination of a large series of specimens may give interesting results.

It has been amply demonstrated in many species of locusts that during periods when they are not to be seen in the form of swarms, they exist as scattered individuals of the *solitary* phase. Detailed investigations carried out in the Indian area between 1931 and 1939 have shown that the desert locust continued to exist in the semi-desert areas of Baluchistan, Sind and Rajputana as *solitary* phase individuals, which bred after rainfall and underwent long-distance migrations almost exactly like the *gregaria* swarms, and it was also observed that a change from the *solitaria* to the *gregaria* phase occurred when meteorological conditions favourable for forming dense concentrations and for intensive breeding developed.

So far as the Bombay locust is concerned, very little is known either about the areas of habitat of the *solitary* phase or about its habits and powers of migration except for the scanty data collected by the locust survey staff in the Rajputana area (Rao and Bhatia, 1939). From the latter, it is clear that the migrants noted in the desert appear from outside, possibly from the Aravalli Hill ranges or from the grass areas of Kathiawar. It is also more or less certain that the grass areas on the Western Ghats would contain some of the natural breeding areas of the *solitary phase*, and doubtless similar breeding grounds may exist among the Satpura and Vindhya ranges, and among the hill areas of the Eastern Ghats in North Madras, Orissa and Chota Nagpur.

As the Bombay locust has only a single generation in the year, swarms can be built up only in the event of a succession of two or more years of favourable monsoon rainfall. In the absence of exact information on the habits of the *solitary* phase individuals, and the nature and range of their migrations, it is not advisable to hazard a guess as to the probable conditions under which a new infestation cycle may develop.

Here is apparently a case where thoughtful planning is needed. There is generally a tendency in human affairs to refuse to look at a problem, unless it is serious enough to force itself on our attention. For instance, it was only when the depredations of the desert locust assumed prodigious proportions in 1929 that studies of the locust problem were taken up by the Government, as a result of which information of great help during the present locust outbreak was gathered. Past records show that the Bombay locust assumed serious dimensions twice during the last sixty years: 1878–1884 and 1898–1908. For reasons at present unknown, there have been no serious developments since 1910, and in the absence of exact knowledge of the laws governing its *solitary* phase existence, no attempts at predictions in regard to the future are at all possible.

The data so far gathered are referable to the provinces of Bombay and Madras, and to a certain extent Mysore State. Very scanty information is at present available on its incidence in the past in other areas, such as Central India, Central Provinces, Hyderabad State, Orissa, Chota Nagpur, Bengal and Bihar. It is possible that records of swarm flights and damage to crops may be found in the season and crop reports of these areas during the past years. Collection of these data is an important item, which should be included in any scheme of investigations that may be put up in some distant future in regard to a thorough study of the Bombay locust. An examination of specimens of the locust in the collections of the various provinces in India may also give valuable clues as to the season of its incidence and the range of its migrations.

Notes on the Infestation of the Migratory Locust in South India in 1878, based on Studies of Old Records

The migratory locust (*Locusta migratoria* L.) is another of the potential pests of India that may at times assume a serious character. Specimens of the solitary phase are met with in small numbers in almost all parts of India, but so far, no observations appear to have been made anywhere on its breeding habits or on its powers of migration, nor are there any published records of instances of local multiplication.

Observations made in the course of locust surveys carried out in the desert areas of Baluchistan, Sind and Rajputana during 1931–1938 have thrown very interesting light on the

migration and breeding of the *solitary* phase of this species (Rao and Bhatia, 1939). In the year 1937 especially, valuable data were obtained which showed how this locust bred in large numbers in spring in the hill-valleys of Baluchistan, and migrated in summer over a distance of over 300 miles to the desert areas of Bikaner and Jaipur, and bred there in July-August. The new generation of adults produced here migrated with the cyclonic winds accompanying a depression from the Bay of Bengal in September into the Palanpur, Sirohi and Mehsana areas of Western India and gave rise to large bands of gregarious hoppers there. The hopper infestations found attacking millets in the Sirohi and Mehsana areas in October, 1937 should have been pronounced to have resulted solely from intense local multiplication, if the earlier data in regard to the breeding in Baluchistan and Bikaner had not been collected already.

Mention made by Cotes (1891) in the *Indian Museum Notes* of a great locust invasion in Madras in 1878 prompted me to seek the original records for studying the data, if possible, in correlation with rainfall and seasonal winds. With the kind help of the Government of Madras, printed records of the Proceedings of the Board of Revenue pertaining to the locust infestation of 1878 were obtained in 1938 and studied. Subsequently in 1941, further records were examined with permission at the Madras Records Office, and recently in 1942, data on the prevalence of locusts in 1878 in the Mysore State were, with the kind courtesy of the Chief Secretary to Government, Bangalore, extracted from the *Mysore Gazette* for 1878. As a result of studying the information thus gathered, and correlating them with the available meteorological data, it has been possible to make a rough conjecture as to the conditions under which the infestation had probably originated and to outline the probable course of its history. A detailed account of the infestation is proposed to be written up in due course, after collecting some further data not available at present, but in the meanwhile, a brief account of the outbreak as far as it can be ascertained from the data on hand will be given below.

The nature of the records.—The records in question are in the form of printed Proceedings of the Board of Revenue, and Orders of the Government of Madras on reports received from the Collectors of various districts on the movements of locust swarms and on the damage done to crops. Some of them deal with correspondence with Dr. Bidie, then Superintendent of the Madras Central Museum, and Dr. Shortt, a retired Surgeon-Major of the Medical Service, on the subject of identifications of the specimens sent to them. The records are, on the whole, fairly complete and cover almost the whole course of the infestation. Indeed, it is seen from one of the Proceedings of 1883 that most of these records had already been studied by Mr. A. J. Stuart, Collector of North Arcot at the time, and attempts had

been made by him at drawing certain general conclusions. He was rather inclined to suppose that the infestation had originated by an incursion of swarms, carried into India from across the ocean by the south-west winds. He also considered that the final disappearance of locusts at the end of 1878 was similarly due to their being driven into the Bay of Bengal by the agency of the south-west current. Various other deductions, made by him on the life-history of the locust in the course of his report, look rather unconvincing in the light of the highly developed locust lore of modern days.

The identity of the locust.—In a note on the locust invasion of 1878, Cotes (1891) gives a brief summary of the course taken by the invasion in South India, and observed, in regard to the identity of the locust concerned, 'nothing seems to have been ascertained at the time of the invasion, though the insects were spoken of in one of the reports as belonging to the species *Locusta migratoria*'. A set of specimens furnished by the Madras Central Museum as representing the locust of 1878 was examined by Dr. Henri de Saussure and consigned to no less than six species of Acrididae, consisting mostly of ordinary grasshoppers —species of *Acridium, Tryxalis, Euprepocnemis*, etc., and only one specimen in a very poor state of preservation being found to be *Pachytylus migratorius* or *P. cinerascens*. There is little doubt that the set furnished was from random collections made by village officers in fields damaged after the main swarms had flown away, and naturally ordinary grasshoppers must have figured largely in such collections. Since no authentic specimens are now available for inspection, and since an infestation of a similar character has not developed in South India since 1878, it is not possible to make any positive statement in regard to its identity. Fortunately, however, there are some definite clues in the body of the records to indicate its identity: (1) the gregarious hoppers found attacking crops in January, 1878 in the Tinnevelly district were described to have been of 'reddish-brown' colour, and (2) the young insects (hoppers) observed in the Krishnagiri taluq of Salem district in August, 1878 were said to have been 'black and gold'. The coloration would indicate that the hoppers were definitely the young stages of *Locusta migratoria*. Again, in the case of pairing locusts in the neighbourhood of Coimbatore in April, 1878, the males were said to have been very small and of a green colour, which is true of the *transiens* and *solitary* phases of *Locusta*, and in another case of migrating swarms found in the Salem district on 27th July, 1878, the males are stated to have been yellow and the females brown in colour, characteristic of the *gregaria* phase. Surgeon-Major Shortt, who had received specimens of the locust from the Collectors of various districts, reported that they were variously coloured, some being spotted, others

brown, yellow or green, which again is indicative of the migratory locust. There seems to be, on the whole, little to doubt that the Madras locust of 1878 was *Locusta migratoria* L.

The history of the infestation.—The earliest information on record is a report from the Collector of Trichinopoly (5th January, 1878) regarding a heavy infestation of crops in about 70 villages in the Perambalur taluq and the northern part of the Trichinopoly taluq (probably in December, 1877). The crops affected were *Cholam* (Sorghum) and *Cumbu* (Bajri) and apparently both hoppers and adults were present. Similarly, the Collector of Madura reported the occurrence of locust damage in January-February, 1878 in the Kamuti, Rajasingamangalam, and Pallimadam taluqs (of the present Ramnad district), and the Collector of Tinnevelly of a heavy attack of hoppers and adults in the Ottapidaram and Sattur taluqs at about the same time. Cotton was reported to have remained untouched. During March, 1878 heavy breeding was reported from the planting areas of the Anamallai Hills.

From the meteorological data available, it would appear that during 1877, there was a serious shortage of rainfall in July-August, following which heavy rainfall occurred in September-October in most parts of the Peninsula. In addition, the north-east monsoon would appear to have been specially active in the coastal districts of the south in November-December. It is presumed that a widespread breeding of the *solitary* phase of *Locusta* had taken place in September-October in most parts of the south of India, and that the adult locusts bred in these areas had been swept down in a southerly or south-westerly direction by the cyclonic winds of the N.E. monsoon into the southern districts of the Presidency during November and December. Favoured by the high rainfall, dense egg-laying appears to have followed, leading to the development of heavy infestation in the Trichinopoly, Ramnad and Tinnevelly districts. Adults appearing in the course of January, February and March, 1878, formed swarms, which soon began flying about the country. Winds prevailing in the south of the Peninsula during February, March and April are variable, but are mostly east to west, south-east to north-west or south to north. Consequently the main direction of the swarms was towards the north or north-west, and flights reached Madura, Coimbatore and Malabar districts from the south. In March, flights passed over the Nilgiris, and reached Wynaad, Coorg and Mysore. In the Mysore State, swarms were recorded in Hassan and Kadur districts by the middle of March, and in the Chitaldrug district in the third week. Flights were recorded in the Kudligi taluq of the Bellary district on 22nd March, and a week or two later in the Hospet, Hadagalli and Harpanahalli taluqs. By the end of March, swarms were reported at Kod and Kalghatgi in Dharwar district of Bombay Presidency; during April,

locusts were observed roundabout Dharwar and Gadag, and by the last week of the month, flights had reached Saundatti in Belgaum district.

Good rainfall occurred in April and May in Coimbatore, Madura and Tinnevelly districts, in most parts of Mysore and in the Bellary district, and as a result, egg-laying by swarms took place in most of these areas in May, and in due course hoppers appeared and attacked the crops in May-June. The hoppers became fledged in June-July, and before long the young swarms were found taking wing. As by this time the south-west monsoon was in full swing, the flights were, on the whole, directed towards the north-east, so that locusts bred in Madura and Tinnevelly were carried gradually into Trichinopoly and Tanjore; those from Malabar and Coimbatore into Salem, North Arcot, South Arcot and Chingleput; and those bred in South Mysore, through Bangalore and Kolar districts, into Chittoor and Nellore districts, while those from Kadur, Chitaldrug and Tumkur into Anantapur and Cuddappa districts, and ultimately into Nellore.

As the central districts of Salem, North Arcot and Chittoor, and the districts of the East Coast fall within the rain-shadow of the Western Ghats, the rainfall in the S.W. monsoon period is relatively light. July was comparatively dry, but fairly good rain fell in August and September in the central districts. There was little breeding during this period, except in the Krishnagiri taluq of Salem district in August, and in the vicinity of Chittoor during September. Owing to this paucity of breeding, a progressive diminution in the number and in the density of swarms was noticed by September, 1878. During October-November, comparatively few swarms were reported, the few on record being from South Arcot (October and November) and Nellore (November). In these instances, the direction of swarm flights would appear to have been modified by the winds of the north-east monsoon. The rainfall of the return monsoon was defective in the southern districts in 1878, and there was apparently no swarm breeding anywhere, and it would appear as if the remaining locusts became scattered over the country as solitary individuals, thereby bringing the infestation of 1878 to an end by December.

Flights of the Bombay locust in 1878.—Some of the Board's Proceedings belonging to the period October, 1878 to January, 1879, deal with reports of locust flights that took place in Bellary and Anantapur districts in October, 1878 and in Kistna district (Muktyala, Tenali and Repalle) in November-December, 1878. These, however, were evidently flights of the Bombay locust (as is evident from a reference to their red colour), which had presumably originated from the Dharwar-Belgaum area and had proceeded in an eastern or north-eastern direction during October-November. Heaps of these locusts were said to have

Monthly Rainfall Data in South India including Mysore from August, 1877 *to November,* 1878.

Stations	1877					1878										
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.
Bellary ..	1·97	5·31	8·95	0·52	0·80	..	..	..	1·30	1·90	1·05	3·90	2·90	5·44	4·35	3·37
Chitaldrug ..	1·37	6·68	11·10	0·20	1·40	..	..	..	2·80	3·80	4·65	2·64	4·88	5·15	1·40	0·70
Chittoor ..	4·31	9·13	11·39	6·04	1·17	.	..	..	0·45	1·50	2·18	7·00	11·21	12·26	8·63	4·41.
Hosur ..	1·11	11·15	12·38	4·54	0·20	..	.	.	2·15	4·10	5·48	4·30	9·25	4·00	3·00	2·25
Salem ..	3·26	9·80	12·00	2·25	2·20	.	..	0·10	3·60	4·90	7·45	2·16	5·10	2·90	3·70	3·15
Coimbatore ..	0·57	1·94	12·99	2·50	2·15	0·22	..	..	5·02	1·75	1·00	1·25	1·42	1·84	1·93	2·39
Periakulam ..	..	9·64	14·71	5·31	6·15	1·05	..	..	2·48	8·13	0·82	3·30	4·35	3·00	4·60	6·40
Madura ..	0·95	5·82	16·80	11·20	13·50	2·15	.	..	2·05	6·50	1·10	1·52	7·56	5·25	6·30	4·50
Tinnevelly ..	..	1·72	5·52	15·82	14 60	1·75	..	0·12	3·62	6·67	1·15	..	0·35	1·80	1·12	5·15

been found dead in the fields during the cyclonic weather that prevailed in Kistna district during November-December, 1878.

Flights in the Ganjam district.—Three of the Proceedings of 1878 refer to reports received from the Collector of Ganjam regarding locust flights that had taken place in the Ganjam district in June and September, 1878. The flights appear to have occurred in the hill areas (2,000 to 4,000 ft. high) known locally as 'Maliahs'. The general direction of swarm movements in June was from west to east, and they would appear to have come from the low-lying valleys, situated to the west in the territories of Orissa and the Central Provinces, and passed over the Balliguda and Goomsur Maliahs north-eastwards into Boad. There are no indications that breeding had occurred, though the standing crops were said to have been damaged. There is no clue in the descriptions of damage given as to the species of locust concerned in these attacks, though it is probable that it was *Locusta*. Cotes (1891), quoting from C. N. Ghosh's Report of 25th February, 1890, states that 'locusts appeared in small numbers in 1878 in Orissa, but did no appreciable damage', and it is not improbable that these were part of those emerging from the Ganjam Maliahs.

Flights in 1881, 1885 and 1886.—Board's Proceedings for the years 1879 to 1886 were examined, among which references to the appearances of small locust swarms (presumed to be of *Locusta*) are found during the years 1881, 1885 and 1886. *In 1881*, the Collector of Madura reported the appearance of a swarm of small locusts in a few villages of Tirumangalam taluq in the month of April. It was stated that they injured the crops a little and perished in the rains that fell 4 or 5 days later (possibly meaning that they disappeared). *In 1885*, there were three reports, of which one referred to locusts that appeared in crowds at Mangalam village in Madura taluq early in July, 1885 and damaged the crops. In the case of the second, it was reported that a locust swarm appeared on the morning of the 3rd August, 1885 at Kothamangalam in Lalgudi division of the Trichinopoly taluq from the western direction, and after attacking sugarcane, *Ragi* and *Samba* Paddy, flew towards the east after three days. In a third case the Collector of South Arcot reported the appearance of locusts in the Vriddhachalam taluq in September, when they bred in large numbers and damaged the crops severely. *In 1886* the Collector of Madura reported the destruction of young gingelly crops in Periakulam taluq about the 10th June, 1886 by a certain kind of locusts (which were, on reference, declared by Mr. Edgar Thurston, Superintendent, Central Museum, Madras, to be the 'true locust'—presumably *Locusta migratoria*). Except perhaps in the last case, it is not possible to say which species was concerned in these attacks, but on account of the coincidence in the time of occurrence and in the circumstances connected therewith, the species

was most likely to have been *Locusta*, as in 1878. It has not yet been possible to examine records later than 1886, but to the best of my knowledge there has not been any outbreak of *Locusta* in Madras since 1906, when I joined the Madras Agricultural Department.

The probable origin of the 1878 infestation.—It is, of course, rather difficult to say, at this distance of time, how exactly the locust outbreak had originated. Even at the time of the invasion, however, it was the opinion of more than one responsible officer that the locust trouble had some connection with the occurrence of abnormally heavy rainfall during the last four months of 1877, following a long period of scanty rain during 1876-77. It is surmised that in 1876-77, while the general drought lasted, the breeding of insects in general, and of migrating insects like locusts in particular, was restricted to and concentrated in a few places where local rain had fallen. Generally, even in years of drought, hill areas get more rain than the plains, and there is little doubt that small concentrations of *Locusta* had formed on the hill areas. In more than one report of 1878, it was mentioned that breeding had occurred in the grass areas along the hill-flanks, and in some it was reported that locust hoppers had invaded cultivation from the hills. Uvarov (1936) also mentions that, in the case of outbreaks of the Oriental Migratory locust—*Locusta migratoria manilensis* Mey.—in the Philippines and Borneo, they are associated with grass areas connected with shifting cultivation on the hills. Since shifting cultivation is quite in vogue on the hills of South India, it is probable that the outbreak centres of 1878 invasion had developed on the hill-flanks of the Western Ghats, the Shevaroys, the Kollimalis, the Pachamalais and other hill-ranges. Incipient swarming, begun on the hill-flanks in 1876-77, had probably become intensified on the plains during the heavy rains of August-September-October, 1877.

The need for further work on an All-India basis on locusts and other migrating pests

The case of the great locust infestation of South India in 1878, described above, is extremely interesting from many points of view. First, there is a general supposition that South India is free from locust trouble, as contrasted with Northern India liable to the invasions of the desert locust, and the north of the Peninsula which is subject to the attacks of the Bombay locust. It has now been shown that in 1878 there was severe infestation which had covered almost the whole of the Carnatic and Mysore, and part of the Deccan. Though it is true that the invasion was an abnormal development due to unusual drought conditions in 1876, it would show there is nowhere a real immunity in South India. If the real outbreak

centres are situated in the grass areas of the hill ranges, there is every likelihood of a recurrence of locust outbreak if the conditions should be favourable. It would, therefore, be necessary to study the ecological conditions of these areas and keep them under constant watch, if needed. It should be recalled in this connection that the migratory locust had suddenly assumed serious dimensions in the Rajputana and Gujarat areas in 1937, and there is, therefore, a need of studying the seasonal distribution and ecology of the locust throughout the Indian areas.

Secondly, the present is a perfectly good instance of the usefulness of studying old records. In this case, thanks to the interest taken by the district administrative officers and the Government of that period, a full record of the reports of movements received from time to time has been preserved in the printed proceedings, from a study of which it has now been possible to reconstruct a fairly complete history of the infestation, although the data are over 60 years old. The story of this locust invasion of 1878 recovered from its burial among records may almost be compared to the recovery of an ancient fossil in flesh and blood from the bowels of the earth. Although the records may not be perfect in every case, there is valuable information in many of them which it would be useful to extract before the records themselves succumb to the ravages of time.

Thirdly, the data have been studied in correlation with available meteorological information, and have been found to fit well with one another, so that a reasonable and cogent explanation of the various events has been obtainable.

In the case of the Bombay locust, the last time it was very active in India was during the period 1898 to 1908. Since then, for some reason not ascertainable at present, the locust has been in a more or less quiescent condition. With the exception of a few swarms appearing in certain years rather sporadically in parts of the area, there has been no serious infestation. The situation is at present so calm that nobody seems to be worried about the future. I am rather inclined to think that, if by some chance the locust had given a serious manifestation of its existence at about the same time as the desert locust, the numerous lacunae in our knowledge of this pest would by this time have been filled up. At the present moment, very little is known about its solitary phase—its habits, its powers of migration, its outbreak centres, its ecology and its distribution. The present time, when swarms are absent, would be the best for investigations of the solitary phase, and if by chance swarms begin to appear, it would be too late to commence the studies. With a fuller knowledge of the locust, we should be in a better position to face a new outbreak; otherwise. India would be caught napping when the next appearance of the pest takes us by surprise.

Similarly, there is a good deal we have yet to know about other insects with migrating capacities. For example, nobody knows about the range of migrations of the moths of the Armyworm or the Cutworm, nor what attracts them to young crops from afar. There is reason to believe that conditions of temperature and moisture have much to do with the appearance of the pest in the places attacked, and also that, in the case of *Spodoptera*, the nature of the rainfall at the season of incidence determines the liability to attack. A thorough eco-climatic study of such situations, as well as studies in the correlation of rainfall and other meteorological data with records of attack during the past three decades in the different areas of India are indicated.

The real need at the present moment would appear to be a system of planning out research on an all-India basis by a central body of agricultural scientists, including entomologists, who should select such problems as cannot obviously be tackled by a provincial agency for being taken up as schemes on an all-India basis. Such problems may include investigation on pests capable of migrating from one province to another, like the Bombay locust, the Deccan grasshopper and the Army-worms, and research in matters of fundamental importance (not already undertaken by the Imperial Agricultural Research Institute) capable of being taken up as separate schemes. In addition, there are pests of widespread occurrence in India on which research and control work is being done in the provinces independently. Very often the results of such work remain for a long time unpublished for want of time and opportunities. If an arrangement could be made to have such results on particular pests periodically collected and examined by a central agency, it would contribute to a prevention of much overlapping in research, and also to a pooling of knowledge that would be of use to the whole of India. The recommendations of such a body could then be considered by central organizations like that of the Imperial Council of Agricultural Research for sanction of funds. It is only then that the present anomalous position, in which no one in particular would appear to be responsible for the neglect of the investigation of a pest of all-India importance like the Bombay locust, could be obviated.

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SECTION OF PHYSIOLOGY

President:—B. Narayana, M.Sc., M.B., Ph.D., F.R.S.E.

Presidential Address

(*Delivered on Jan. 4, 1943*)

THE GROWTH OF PHYSIOLOGY AS AN EXPERIMENTAL SCIENCE

Introduction

I feel it a signal honour to have been asked to preside over the Physiology Section of the 30th Session of the Indian Science Congress. I had the least hesitation in accepting the onerous duty of presidentship as I was sure of the help and co-operation of my various friends and colleagues in its discharge.

I have chosen for my address today 'the growth of physiology as an experimental science' as I think this to be an ideal opportunity for tracing its growth as such and presenting before you not only the researches done in the past but also those that have been done in recent years and have involved high degree of experimental technique. In doing so it is only natural for me to go back to the earliest days when physiology as such was not known and then to describe how and under what conditions it has achieved its present position. Physiology is intimately connected with anatomy; it has its application to various problems in medicine and surgery. It would be natural, therefore, for me to refer to the above in the course of my address.

On the question of the range and position of physiological science as a branch of knowledge and its value as a means of mental discipline I would quote a few words from Huxley (1902-03). He answers this question as follows: 'Its *subject matter* is a large moiety of the universe—its *position* is midway between the physico-chemical and the social sciences. Its *value* as a branch of discipline is partly that which it has in common with all sciences—the training and strengthening of common sense; partly that which is more peculiar to itself—the great exercise which it affords to the faculties of observation and comparison; and I may add, the *exactness* of knowledge which it requires on the part of those among its votaries who desire to extend its boundaries.' One may add also to this, in the words

of Bayliss (1924), 'the great experimental skill demanded, owing to the complexity of the phenomena studied'. The great experimentalist Claude Bernard says that physiology is to be regarded as an independent study and is to be cultivated for its own sake and not merely for its application to the practice of medicine. He further remarks that 'in physiology, more than anywhore alse, on account of the complexity of the subjects of experiment, it is easier to make bad experiments than to be certain what are good experiments, that is to say, comparable. This is the reason of the contradictions so frequent amongst experimenters, and it is one of the chief obstacles to the advancement of medicine and of experimental physiology'.

Keeping in mind the above observations let us now examine how the growth of physiology as an experimental science has taken place and what have been the fruits of the growth in some of the important fields of physiological knowledge. The growth of physiology is intimately connected with the growth of medicine and that of anatomy. It is essential, therefore, for one to go back to the days of Hippocrates for a moment.

Hippocrates.—With Hippocrates, the great Greek physician, born in the island of Cos in 460 B.C., began the era of rational system in medical study, system freed from religious rites and superstitions. Hippocrates was a famous practitioner of medicine as a profession which demanded truth and accuracy in observation and honesty in practice. The 'Hippocratic writings' are a collection of heterogenous works dealing with all the provinces of medicine. A close study, however, shows that they lack uniformity and some of the views expressed are directed against the others. It is impossible, therefore, to believe that these writings were the works of one author. Which, among these various writers, was the true Hipprocates? Which of the scripts are genuine? We do not know. As time passed and the readers became less critical, the body of the works, accepted as Hippocratic, continually grew until at last it came to include almost all the anonymous medical writings of that age. Even though the 'Hippocratic writings' are not homogenous and perhaps may not actually contain a single line penned by Hippocrates, they are still of very great value. They give us a clear idea of the medicine practised during the fifth and at the beginning of the fourth century before Christ. We perceive from these writings that medicine, as practised then, was a highly developed healing art and had succeeded in ridding itself of the magical and religious elements and that it was guarded mainly by observations and experiments. No doctor ever exerted a more far-reaching influence than Hippocrates. To the ancients he was an ideal physician, the perfect embodiment of a specific conception of medical behaviour, the doctor who 'lived his life and practised his art serenely and sacredly'. Each successive epoch formed a new picture of Hippocrates.

What people found wanting in the doctors of their time, they thought of as having existed in Hippocrates.

Post-Hippocratic Period.—In the post-Hippocratic period, two notable schools of medicine were founded in Alexandria, one by Herophilus of Chalcedon (300 B.C.) and the other by Erasistratus (260 B.C.). Herophilus was a very able anatomist of his day. Whereas earlier anatomists had been content to describe the anatomy of the lower animals, Herophilus gave detailed accounts of the organs of human beings. His writings, which have been preserved, show that he was a very careful observer. His description of the membranes of the brain, genital organs and the eye are excellent. It was he who gave duodenum its name. He recognized that the brain was the central organ of the nervous system and the peripheral nerves were meant for sensation. Erasistratus flourished about a generation later than Herophilus. Like Herophilus, Erasistratus was a student of Nature. He described animals and some organs of human beings. He wrote two anatomical books which contain excellent description of the heart with its valves, of the upper air passages with the epiglottis, of the liver and the bile duct and of the brain. He recognized the presence of sensory and motor nerves. Not only did he dissect the human body but he applied the data of his anatomical observations to pathology.

Galenic Period.—From the third century B.C. we may now pass on to the second century A.D. In this century there flourished a physician Galen of Pergamum, the ancient capital of Attalides. He was but one amongst many. During the Middle Ages, he was regarded as authoritative to a degree. Then came the Renaissance when he fell into great disrepute. Galen was born in 129 A.D. He started the study of medicine at the age of 18 and spent nine years upon his travels. He visited a number of places in the pursuit of medical knowledge. Being specially interested in anatomy, he naturally visited Alexandria where there still existed a famous university, and which was once the best place in the ancient world for the study of anatomy. But the Alexandria at the time of his visit was not the same as the one of the time of Herophilus and Erasistratus. Nevertheless, he found the place still suitable to his purpose. Galen had been a voluminous writer and a careful observer and investigator. He was a Hippocratist. Hippocrates was the master to whom he continually referred. His mission was to build upon Hippocratic foundation. In Galen, the ideas of Hippocratic writers were maintained but were given a Galenic stamp. In his old age Galen wrote, 'I have continued my practice until old age, and never as yet I have gone far astray whether in treatment or in prognosis, as have so many other doctors of great reputation. If any one wishes to gain fame through these, and not through clever talk, all that he needs is.

without more ado, to accept what I have been able to establish by zealous research.' Those words were prophetic. Galen's successors regarded Galen as an unchallengeable authority and were only too loath to make their own investigations.

The Dawn of Modern Science

From the beginning of the fourteenth century the dissection of corpses had been going on. The days of anatomical demonstrations were red-letter days in the academic calendar. The corpse of an executed criminal was placed by the authorities at the disposal of the university and the professor would demonstrate to the doctors and the students. When the Renaissance was in its bloom, corpses were more readily obtained and there were doctors who could boast of having dissected a large number of dead bodies. But all of them looked through Galen's spectacles and Galen's anatomical works were in every one's hands. The birth of the modern science of anatomy and physiology began from the time of Andreas Vaselius, who was born on New Year's night, 1514-15. He went to school at Louvain and studied medicine and anatomy at Paris where he tasted to the full the whole Galenic doctrine of the age. The outbreak of war made it necessary for Vaselius to quit Paris. He went to Louvain and Brussels to continue his studies. Italy, the land of the new sciences, had its lure and Vaselius decided to go to Padua. On December 5, 1537, he took his doctor's degree at the university of that town and was appointed professor of surgery and anatomy at the young age of 23 years. Vaselius' attitude was that observations, not authority, were the standards to be followed. With untiring zeal he dissected and so thoroughly did he do it that in a few years his fame was spread throughout Europe. He did not apportion the task of seeking the secrets of Nature, as found in the human body, to the unskilled barbers, he did not point to his students the study of written words but, by precept and example, he showed that knowledge could only be advanced by personal observations and thus he placed the investigation of the structure of the body on a sound scientific basis. He laid the foundation of the experimental methods so securely that his students and disciples never appealed to him as an authority but they appealed for judgment to that which could be seen and demonstrated. By his courage and independence of thought he laid the foundations of modern anatomy, and in so doing, he made possible such further advances in the knowledge of minute structure as paved the way for the investigation of the function of the various parts of the body. Function is intimately related to structure and it is by a study of the structure that we can understand and investigate the function. This young anatomist would dissect animals—dogs and cats, mice, rats and moles, whatever he could get hold of. No animal

was safe from him. He frequented the cemetery or the place of execution in search of bones for his study. At this time there was no trustworthy book on human anatomy, and Vaselius, realizing the importance of such a book for doctors, decided to write one. In June 1543 his book entitled 'The Fabric of the Human Anatomy' was published. This contained 663 folio pages and over 300 illustrations. Thus the year 1543 stands out conspicuously in the history of anatomy and physiology. Vaselius was dead but his book remained as monument, being the first complete textbook of human anatomy known to history. This book is the beginning not only of modern anatomy but of modern physiology as well.

The seed sown at Padua had borne good fruit. One of the successors of Vaselius, Colombus, had succeeded in proving that blood flows out of the heart into the lungs and through the lungs back into the heart. Colombus was succeeded by Fallopius whose name is immortalized in anatomical nomenclature by the 'Fallopian tubes'. Fallopius was succeeded by Fabricius in 1565. Fabricius ably maintained Padua's fame as a great school of anatomy and was brilliantly successful.

Amongst the pupils of Fabricius, one of the most diligent was William Harvey. Harvey was born on 1st April, 1578. Having taken his B.A. degree at Cambridge, he proceeded to Padua for the study of medicine. A student who has worked in Padua, the workshop of anatomy, was apt to be a keen anatomist all his life. So was William Harvey. But he did not like to be content with pure anatomical observations. Function stood in the foreground of his interest. Harvey dissected innumerable animals. He saw and felt the heart beat. He argued within himself the causes of its movement. By degrees the problem began to clarify. In the year 1628, he felt sure that the soundness of his theory had been established beyond the possibility of doubt and published his 'Exercitatio' presenting his ideas concerning the movements of the heart and of the blood. Harvey concluded that the systole was the active phase of the heart movement and during this period blood was driven into the great arteries. According to his estimate the amount of blood ejected by the heart during the systole was two fluid ounces. With the heart beating 72 times per minute, the quantity of blood ejected in an hour will be $2 \times 72 \times 60 = 8,640$ fluid ounces. Harvey argued within himself as to the source of this vast quantity of blood. Was it from the food? or was it by incessant new formation? Where does the blood go? Does it ooze away into tissues? These ideas did not appeal to him. There could then be no other possibility than that the blood must get back out of the arteries into the heart and the only channels whereby it could reach the heart were the veins. The circle was complete. From the left side of the heart, the blood flowed through the arteries into all parts of the organism, made

its way through gaps in the tissues into the veins to be conveyed by them to the right auricle of the heart and through this into the right ventricle. The blood then flowed through the lungs and back through the pulmonary veins to the heart again, first to the left auricle and then to the left ventricle.

Harvey was an anatomist but in his hands anatomy took a new shape, became physiology. It became physiology of a very different kind from any that had previously existed. From this time onwards physiology was inseparably associated with anatomy and physiological explanation was acceptable only if it was anatomically possible. Harvey's great exposition of the circulation of the blood did for physiology what Vaselius' Fabrica did for anatomy, it rendered progress possible. Harvey, however, failed to discover how the blood made its way from the arteries to the veins. Obviously, there must be channels of some sort by which the circulating blood passed but their nature remained obscure. It was for Malpighi, in the year 1661, to demonstrate the existence of capillaries and prove that the blood passed from arteries into the veins not through vague lacunae in the tissues but through extremely minute vessels, the capillaries, which existed in all parts of the body.

Physiologists in the Nineteenth Century

Coming now to the nineteenth century, physiologists like Johannes Muller, Helmholtz and Ludwig in Germany and Claude Bernard in France had considerable influence on the growth of physiology in Europe. People flocked to their laboratories for learning the experimental technique. Johannes Muller was a voluminous writer. He was greatly interested not only in physiology but also in zoology, comparative anatomy and embryology. Whatever subject he touched, he gave an added depth to it. He finds an important place among scientists because of the influence he exerted throughout Germany upon scientific medicine. Muller was a student at the University of Bonn where he took his degree. Then he removed to Berlin where he made acquaintance of Rudolphi, the physiologist, who influenced him strongly. In 1830 he was made professor of anatomy, physiology and pathology at Bonn where he made a thorough study of the nervous system and the sense organs. He published a comparative physiology of vision, a work in which he discussed the mechanism of sensation and its relation to mental activity. Muller's investigation concerning the composition of the blood and his discovery of chondrin deserve special mention. One of the finest of his physiological achievements during his days at Berlin was his study of the way in which the tones of the voice are produced in the larynx.

Helmholtz was a physiologist though his chief interest was in physics. As far as physiology was concerned, he devoted

himself mainly to the physical aspects of the science. He made observations upon the velocity of nerve conduction and of reflex processes. Helmholtz devoted himself to the study of the physiology of sense organs. He discovered the ophthalmoscope with the aid of which the fundus of the eye could be examined and this discovery affords a striking demonstration of the practical importance of theoretical studies in the field of medicine. With the ophthalmoscope the physician could see directly into the interior of one of the bodily organs, could see morbid changes more effectively than the pathologist could observe them on the post-mortem table.

During the seventies of the nineteenth century, Leipzig was the centre of physiological activity in Europe. Here, Carl Ludwig attracted workers from all parts. Those who had the privilege of conducting researches with him also made the acquaintance of men like Pavlov in Russia, Mosso and Luciani in Italy, Buchner in Bavaria and his chief assistants Kronecker, Drechsel and Flechsig, who became leaders in physiology in their respective countries. Ludwig invented the graphic method of recording blood pressure which made exact investigation of phenomenon of circulation possible.

The influence of Claude Bernard on the development of physiology as an experimental science was considerable. Bernard was a Burgundian, the son of a vine-grower. He became a student of medicine and came under the influence of Magendie who took him as his assistant. According to Magendie the only possible method of investigation was experiment and he dreaded speculation greatly. It was in this rigid experimental school that Claude Bernard grew up. Claude Bernard had to work in a damp gloomy room in the *College de France*. The apparatus he used was constructed by himself amid great difficulties. Experiments on animals attracted the police attention. By ill luck, one day, a dog with a silver cannula protruding from its belly wall escaped from the laboratory. Bernard was prosecuted but he explained the circumstances and secured a respectful hearing. In his hands, physiology had become a pure natural science. Bernard devoted his primary attention to the physiology of digestion and studied the course taken by nutritive materials when introduced into the organism. He began with the study of the gastric juice and its rôle in digestion. Then he worked with other digestive juices, viz. salivary and pancreatic. He was greatly interested in the fate of the carbohydrates in the body. He was able to show that sugar is always present in the blood and that the sugar of the body is mainly stored in the liver and partly in the muscle but as glycogen. In 1849 he discovered 'the sugar puncture' in which the puncture of a particular spot in the medulla was found to load the blood with sugar. It was shown that this puncture led to a stimulation of the sympathetic system. Bernard was now led into a new

field of work. He began to study the effect of the sympathetic system upon other organs, specially upon blood vessels. In a series of papers he discussed the working of the vasomotor nerves. In his hand physiology became a highly developed experimental science. Claude Bernard's fame grew far and wide. But the rise of Pasteur to fame, which was soon to follow, was to thrust Claude Bernard's name into the background. This was an injustice. Although Bernard's discoveries were less striking in some respects than those of Pasteur, they were quite as important to scientific medicine.

It is unfortunate that physiology was not so highly developed as an experimental science in Great Britain as on the continent. On the continent there were established chairs in physiology occupied by notable physiologists whereas in Great Britain physiology was looked upon little more than a branch of anatomy. This neglect of physiology is all the more remarkable when we remember that the foundation of physiology was laid by William Harvey who was an Englishman. It was not until 1836 that a chair of physiology was established in a medical school in Britain—it was the University College, London. William Sharpey, a man of considerable experience, was appointed to this chair. Sharpey, though essentially an anatomist, had a sound theoretical knowledge of physiology and was a very keen teacher. He devoted considerable part of his lecture to minute anatomy (histology) as he realized that intimate knowledge of structure must precede the investigation of function. He had never used a kymograph. The only apparatus he had was a microscope. Nevertheless, his influence on the spread of physiology as an experimental science was considerable. He early recognized the importance of the practical study of the subject and instituted a course of practical instruction. He induced George Harley, a rising physician who had worked in Paris with Bernard, to start a class of practical physiology. But Harley, with a growing practice, found it impossible to continue. Sharpey then persuaded Michael Foster, a student of the University College, to give up practice and come to the College as the first professor of practical physiology, a chair specially created for him.

Foster himself had no special training in physiology but from visits to the continent he had learned what was being done there. The course in practical physiology consisted of examinations of teased preparations and of section of organs made with razor, study of the constituents of blood and serum, bile and urine, phenomena of gastric and pancreatic digestions and general properties of albumins, carbohydrates and fats, the phenomena of nerve and muscle physiology, the action of the heart and the circulation in the frog and in the mammal. His activities here did not continue for long. The Trinity College, Cambridge, established a Prelectorship of physiology and Foster

was asked to occupy this new position. In 1870 he left London and went over to Cambridge to take this up. His place in the University College was taken up by John Scott Burdon Sanderson but after Sharpey's retirement in 1870 he succeeded him as the professor of physiology continuing also to be the professor of practical physiology.

Physiology owes a deep debt of gratitude to Michael Foster as he took an active part in founding the British Physiological Society in 1876, in establishing International Physiological Congress, and in starting the *Journal of Physiology*. He had a number of keen young workers under him who have made valuable contributions to science. Prominent amongst them are Francis Martland Balfour, Walter Gaskell, John Newport Langley and Charles Scott Sherrington. His textbook of physiology which was first published in 1877 in English language filled a real want and it went through three editions, each an improvement over the other. On Foster's retirement in 1903, Langley was elected to the chair and on Langley's death in 1925, Joseph Barcroft succeeded him. Barcroft on his retirement was succeeded by Adrian in 1937.

In the University College, London, while Burdon Sanderson was still the professor, Edward Albert Schafer joined as the assistant professor in 1874 and was elevated to professorship when Burdon Sanderson left London to take up his new appointment at Oxford as Waynflete professor of physiology. On Schafer's transfer to Edinburgh in 1899, Ernest H. Starling succeeded him and on Starling's appointment to one of the Foulerian research professorships of the Royal Society, Archibald Vivian Hill was elected to the chair. On Starling's death, Hill succeeded him as the Foulerian professor and C. Lovatt Evans succeeded Hill. The traditions of the University College were carried to Oxford by Burdon Sanderson and to Edinburgh by Schafer.

Centres of Physiological Research in Great Britain

The University College, London, and the Universities of Cambridge, Oxford and Edinburgh developed into important centres for physiological research and formed nuclei for producing keen and able research workers in the science of physiology. Gradually, other universities also improved their laboratories, encouraged workers and added to the existing knowledge on the subject. Research workers from the continent of Europe, from the United States of America, from India and from the Far East poured in and added to the group of experimentalists.

Let us now look into the work done at the various centres of physiological research during the nineteenth century up to this date. Amongst the workers at Cambridge, Balfour came under

the notice of Michael Foster in 1870. He began investigations on embryology, commencing with the chick. His work on the development of Elasmobranch proved to be of very great importance. Gaskell entered Trinity College in 1865. He was one of the first to benefit by the guidance of Foster. He had also spent a year at Leipzig under Ludwig. He worked there on the changes in the blood vessels of muscle accompanying its contraction. On returning to Cambridge he worked on the causation of the heart beat and showed that the contraction arose in the muscular tissue itself. This work will always keep Gaskell's name in high position. From the study of cardiac contractions he was led to investigate the origin of vascular and visceral nerves in general and was the first to give a clear account of the origin of the sympathetic nerves from the spinal cord. Langley entered St. John's College, Cambridge, in 1871. His first work was on the action of pilocarpin on the heart and later he worked on the influence of nerves and drugs on secretions and then on the origin and course of the autonomic nervous system. The work of Keith Lucas on the application of physics to the problems of physiology and the ingenious types of apparatus and experiments devised by him really form an interesting reading. Barcroft's work on the physiology of blood and respiration has been of very great value to the science and although he retired from the chair of physiology at Cambridge not long ago he is still continuing to help the growth of physiology as a science by his researches.

Coming now to the University College, London, Burdon Sanderson worked on problems of electro-physiology which he continued also at Oxford. His successor at Oxford, Gotch, also interested himself in electro-physiology. Schafer, the successor of Burdon Sanderson at the University College, was one of the most eminent persons of his time. His work covered vast fields of research. His histological researches, his work on the functions of the endocrine glands, his investigations on problems of respiration and lastly his method of artificial respiration will long be remembered although he is dead now. Schafer always felt that physiology, in order to progress, must keep within its sphere the study of histology and biochemistry and he was never for the separation of these departments from physiology. He developed the physiology department at Edinburgh to a very high level, he attracted workers from all over the world and his students are now filling up a large number of high teaching appointments in different universities. Starling is very well known to the physiology world as the author of the well-known book on physiology, as an experimenter of very high ability and as a successful teacher. His 'heart lung preparation' is a very well-known technique and has been of very great use in solving problems on the cardio-vascular system and specially on the coronary circulation.

William Maddox Bayliss, who was holding the chair of general physiology in the University College, carried on most of his investigations in collaboration with Starling. His work on the action of heart, on the secretion of pancreas and on the movements of the intestine were all done along with Starling. Bayliss has written a masterpiece book on general physiology, the like of which has never been written before. At Oxford, Sir Charles Sherrington, the successor of Gotch, worked principally on the physiology of the spinal cord and his book, 'The Reflex Activity of the Spinal Cord', of which he is the senior author is an authoritative monograph on the subject.

Other Important Researches

The work of Pavlov, the Russian physiologist, on conditioned reflexes embodies the highest quality of experimental technique and although Pavlov is no more, he will be remembered by workers all over the world for having undertaken and successfully carried out such an intricate piece of observation. The work of Heymans, the Belgian physiologist, on the functions of the carotid sinus is another brilliant piece of investigation and shows a very high quality of experimental technique adopted by him and his collaborators. The work of Loewi and of Dale on the humoral transmission of nervous impulse brought forward an entirely new conception of the mode of action of autonomic nerves. The researches of Magnus of Utrecht on postural reflexes form another masterpiece work from the experimental technique point of view. Adrian of Cambridge has opened newer lines of investigations in the field of action currents. A. V. Hill's work on physico-physiological problems like heat production in muscle and nerve has added an interesting field of investigation. Lapicques' work on chronaxie, Eggleton's work on the chemistry of muscular contraction, and Roughton's work on the problems of carbon dioxide carriage, have brought in the field of physiological investigations more interesting problems and have attracted men of varied interests and have thus put physiology again in the forefront of experimental sciences. The fine experimental technique of Lovatt Evans of the isolated heart preparation for the study of the metabolism of cardiac muscle and of Daly for the perfusion of lung vessels form examples of high class research methods employed to solve physiological problems. Haldane's work for the welfare of miners goes only to show the importance of physiological researches for the benefit of the industries. Then again, work such as that of Sir Thomas Lewis on the investigation of cardiac function requires more than the brilliant mind of the investigator, it demands the support of a sound organization, and a good deal of personal sacrifice of those engaged. Last but not the least, the work of Banting and

Best on Insulin has done a lasting service to humanity, and will be remembered till posterity.

Having given a brief review of work done by various physiologists at different centres, I think I would be failing in my duty if I do not discuss more fully one of the important subjects in which work has been done in recent years and further work is in progress here and at other centres of research. For this I have selected to speak to you on the Physiology of the Pulmonary and Bronchial Vascular Systems.

THE PHYSIOLOGY OF THE PULMONARY AND BRONCHIAL VASCULAR SYSTEMS

The lungs and the tubes are supplied with blood through the pulmonary and the bronchial arteries. The distribution of the bronchial arteries within the lung has been investigated by many anatomists but nothing definite was known of their physiological significance beyond the fact that they are nutritional vessels to the bronchial tree. Some of the earlier workers on human lungs (Haller, 1756; Reisseissen, 1822; Kuttner, 1878) described arterial anastomosis between the pulmonary and bronchial vascular systems whereas other workers (Guillot, 1845; Rossignol, 1846; and Miller, 1900, 1906, 1925) found the two arterial systems to be independent. Evidence of capillary anastomosis between the pulmonary and bronchial vascular systems has been produced by Reisseissen (1822), Kuttner (1878) and Miller (1906, 1911, 1925, 1925*a*). According to Miller (1925) the bronchial arteries supply the bronchial tree as far as the small bronchioles. With the appearance of alveoli along the walls of the bronchioles, the bronchial arteries, as a distinct set of vessels, disappear and the terminal network of capillaries formed by them unite with that of the pulmonary artery in the region of the *bronchioli respiratorii*. Beyond this region, the air tubes and air spaces are supplied by the pulmonary artery. Regarding the venous communication between the larger branches of the pulmonary and the bronchial veins, Reisseissen and Sommering (1808) and Zuckerkandl (1881) found them to be present but Hyrtl (1873) and Sappey (1889) denied their existence.

More recently, Berry, Brailsford and Daly (1931) investigated the course and distribution of the bronchial arteries in the dog and the degree of vascular anastomosis between the bronchial and pulmonary vascular systems by injecting Prussian blue gelatin or carmine gelatin dye or barium sulphate gelatin mixture by way of the pulmonary artery and also by way of either the posterior bronchial arteries or by way of the aorta in conjunction with thoracic parieties and oesophagus or with oesophagus alone. These were designated as isolated lung or lung-thorax-

oesophagus or lung-oesophagus preparations. They found that bronchial arteries in the dog arise in one of the two following ways:—

(*a*) The posterior bronchial artery arises from the sixth intercostal artery and divides into a right and left branch. The anterior bronchial arteries arise from the internal mammary and from the pericardial arteries of the same side.

(*b*) A branch from the right fifth or sixth intercostal artery going to the right lung and one or more twigs direct from the first part of the descending thoracic aorta or a single twig from the left sixth intercostal artery going to the left lung constitute the posterior bronchial arteries. The anterior bronchial arteries arise from the internal mammary artery, the mediastinal and the pericardial arteries of the same side.

They did not find any evidence of extensive arterial or venous communications between the bronchial and pulmonary vascular systems, the capillaries and possibly the smallest arterioles and venules serving as the only means of direct communication. Berry and Daly (1931), working further on the problem, perfused simultaneously, under negative pressure ventilation, the pulmonary and the bronchial vascular systems. One pump was connected with the pulmonary artery and supplied blood to the portion of the respiratory tree which included and was lying between the respiratory bronchioles and the alveoli. The outflowing blood from the pulmonary veins was collected in the pulmonary venous reservoir. The second pump connected to the bronchial arteries supplied blood to the proximal portion of the respiratory tree as far as the respiratory bronchioles, and also to the specialized tissues of the lung. The bronchial venous blood from the first, second and third order of bronchi drained, by way of bronchial veins, into the bronchial venous reservoir and that from the smaller bronchi, as far as the respiratory bronchioles, passed by way of the pulmonary veins into the pulmonary venous reservoir. Thus, the respiratory bronchioles received blood from a dual source and the larger pulmonary veins received oxygenated blood from the pulmonary circulation as well as venous blood from the bronchial circulation. They observed that alterations in the bronchial arterial pressure led to changes in the pulmonary arterial pressure, the pulmonary venous and the azygos venous flows and came to the conclusion that there was a functional anastomosis between the bronchial and the pulmonary vascular systems.

Reisseissen (1822) in his monograph published as early as 1822 recognized the importance of the bronchial arteries for the nutrition of the lung structures and called them *Vasa nutritia*. This recognition of the nutritional function of the bronchial vascular system for the lungs is of importance both to the experimental physiologist and the pathologist, for the

normal functioning of the intrinsic mechanisms of the lung depends in part upon the integrity of this system.

The greatest obstacle to an accurate analysis of intrinsic pulmonary vascular mechanisms is their almost constant association with cardiac and systemic circulation phenomena. Earlier observers were also aware of these difficulties and therefore they had approached the problem by making simultaneous observations of the pulmonary and systemic pressures during nerve excitations or the exhibition of drugs. Two schools of thought developed—one which considered the pulmonary vascular system to be under a somewhat weak control of the nervous system and the other which denied any active participation of the pulmonary blood vessels in circulatory phenomena, the lesser circulation being regulated by changes in the cardiac output and in the greater circulation. No complete understanding of the nervous mechanism controlling the lung vessels could be arrived at but there was a general agreement that such a control did exist. A history of the problem is to be found in the papers by Daly (1933), Bradford and Dean (1889), Schafer and Lim (1919), Luchardt and Carlson (1921), Schafer (1921), Wiggers (1921) and Tigerstedt (1923). Recent work on the subject shows that the reactions of the various parts of the pulmonary vascular bed to nervous and chemical influences are not always similar and that any given response of the lung as a whole must be considered as the resultant of a number of reactions in different parts.

Experiments on isolated pulmonary vessels and on isolated perfused lungs have played a large part in the investigations and in the case of isolated lung preparations the complications introduced are due to the abnormal perfusate which may be responsible for a diminished sensitivity of the preparations. But the advantages are that the ventilation and perfusion pressure can be maintained constant so that alterations in blood inflow and outflow and blood volume of the lungs may be taken as a certain indication of intrinsic pulmonary phenomena.

Vasomotor Nerves

There was no convincing evidence of the presence of a pulmonary vasomotor control previous to the work of Bradford and Dean (1889*a*, 1894). They demonstrated a rise in pulmonary arterial pressure by stimulation of the peripheral ends of cut thoracic nerves from D2 to D7. Brodie and Dixon (1904) were also able to confirm most of the experimental results of Bradford and Dean. Tribe (1914) found that in the cat, excitation of the stellate ganglion and its branches or of the sympathetic chain immediately below it led to a pure vasoconstriction or one followed by weak vasodilatation. She considered the pulmonary blood vessels to be supplied by

constrictor and dilator fibres of sympathetic origin. The careful researches of Tribe have been largely responsible for the success of later workers in the field. Daly and Euler (1932) observed that the isolated lungs perfused through the pulmonary artery quickly lost their responses—both bronchomotor and vasomotor —to nerve stimulation but when the perfusion of the bronchial and pulmonary vascular beds was done simultaneously, the excitability of the nerve structures receiving blood from the bronchial arteries lasted as long as three hours after commencement of the perfusion.

Experiments carried out by Daly and Euler (1932) in dogs showed that excitation of the cervical vago-sympathetic, of the cervical vagi, of the stellate ganglia or of the thoracic vago-sympathetic nerves caused pulmonary vasoconstriction in some preparations. In others, stimulation of the thoracic vago-sympathetic nerves produced weak vasodilatation. The constrictor responses remained after atropine but were suppressed or reversed after ergotamine and presumably were due to stimulation of adrenergic nerves. The dilator responses were enhanced by eserine and suppressed by atropine and were probably due to excitation of cholinergic nerves.

The vasomotor control of guinea-pig's lungs was investigated by Dale and Narayana (1935). They made a perfused lung preparation using hypertonic Tyrode solution as perfusion fluid. They found that excitation of the cervical vagi caused vasoconstriction—an effect which was abolished by atropine but uneffected by eserine. Excitation of the stellate ganglion caused vasoconstriction in only one experiment. Petrovskaia (1939) found that in the guinea-pig stimulation of the peripheral end of the cut cervical vago-sympathetic nerves caused a rise in intra-pulmonary pressure associated with a diminution or no change in outflow. Stimulation of the peripheral ends of the cut cervical sympathetic nerves produced a rise in intra-pulmonary pressure without any associated change in venous outflow in some experiments, and in others when ergotaminized animals were used, there was a fall in the intra-pulmonary pressure with no significant venous outflow change. Stimulation of the peripheral ends of the cervical vagi caused a rise in intra-pulmonary pressure together with a diminution or no change in the venous outflow.

Sinha (1942) working in my laboratory studied the pulmonary vasomotor control in the guinea-pig and observed vasoconstriction by excitation of the stellate ganglion or of the cervical vagi, the constrictor effects being abolished by ergotamine and atropine respectively. He (1942*a*) observed identical results in rats. Mashima (1921) working with Japanese toads observed vasoconstriction on vagus excitation. Sinha (1942*b*) noticed vasoconstriction in the frog by stimulation of the vago-sympathetic trunk, which effect was partially

abolished by atropine or ergotamine and completely by both, showing thereby that both the vagus and sympathetic fibres to the pulmonary vessels are vasoconstrictors.

In the light of the evidence obtained, it is no longer possible to deny the functional importance of the pulmonary vasomotor nerves. Vasoconstrictor effects have been obtained more often and more strongly than vasodilator. But no great stress should be laid on such a quantitative distinction when applying the results to a normal physiological subject. When we consider that the lung preparations are perfused with defibrinated blood or Ringer and are isolated from the central nervous system as well as from organs whose secretions may profoundly affect the responses of the lung blood vessels, it would be really surprising if artificial excitation of nerves produced effects similar to those produced by nerve impulses emanating from the central nervous system in the normal subject.

Action of Drugs

Schafer and Lim (1919) carried out experiments on entire animals (dog, cat and rabbit) and reached the conclusion that the rise of pulmonary arterial pressure after adrenaline was due partly to pulmonary vasoconstriction and partly to changes in venous filling and output of the heart. Dixon and Hoyle (1929, 1930) drew attention to the fact that adrenaline raises pulmonary arterial pressure by dilating the coronary vessels and increasing the flow to the right heart.

Alcock, Berry and Daly (1935) using isolated lung preparation of the dog, under negative pressure ventilation and perfused with defibrinated blood, observed that acetylcholine in small doses caused a slight fall in pulmonary arterial pressure and in large doses, a rise, the effects being independent of bronchomotor mechanism. The effects were suppressed by atropine and enhanced by eserine. Adrenaline, in small doses, had no effect upon the pulmonary arterial pressure, yet it caused an increase in venous outflow.

Daly, Foggie and Hebb (1940) perfusing isolated dog's lungs, under negative pressure ventilation, obtained no evidence that adrenaline exerted any constant vascular action on dog's lungs perfused with defibrinated blood other than constriction and they were forced to the conclusion that large doses of adrenaline in these preparations caused constriction of all parts of the pulmonary vascular bed including the capillaries and that small doses caused arterial and venous constriction only.

Dale and Narayana (1935) studied the action of drugs in the isolated guinea-pig's lungs perfused through the pulmonary artery with hypertonic Tyrode solution under positive pressure ventilation. While perfusion was going on they recorded the respiratory pressure also with the help of a bromoform manometer.

They observed that injection of acetylcholine caused both vasoconstriction and bronchoconstriction—effects which were abolished by atropine and uneffected by eserine. Injection of adrenaline caused vasoconstriction, and if the tone of the bronchial muscles was already high, as shown by respiratory pressure, bronchodilatation. They further observed that during the action of a drug affecting both bronchi and blood vessels, two mechanisms were responsible for their final effect upon the blood vessels: (*a*) the action of the drug upon the blood vessels and their peripheral elements, and (*b*) the mechanical forces exerted on the blood vessels as a result of concomitant changes in bronchial calibre. The resultant effect was the algebraic sum of the two effects. Foggie (1936) working on the rats observed that small doses of adrenaline caused pulmonary vasodilatation and large doses caused vasoconstriction. Histamine and acetylcholine caused vasoconstriction. The vasoconstrictor response by larger doses of adrenaline was reversed by ergotoxine. Petrovskaia (1939) using isolated perfused lungs with recirculated Ringer-Locke solution observed that acetylcholine raised the intra-pulmonary pressure and diminished the venous outflow, both effects being abolished by atropine. Adrenaline frequently produced a fall in intra-pulmonary pressure together with an increase in venous outflow, but under certain conditions it caused a slight but definite rise in intra-pulmonary pressure and that ergotoxine converted the adrenaline intra-pulmonary rise to a fall.

Petrovskaia (1939) using isolated pig's lungs, under negative pressure ventilation and perfused at constant volume inflow with defibrinated blood, observed that adrenaline reduced the pulmonary arterial pressure in freshly perfused preparations and augmented it during later stages of perfusion. Ergotoxine reversed the pressure effect. Small doses of acetylcholine tended to lower and larger doses to raise the pulmonary arterial pressure in ergotoxinized preparations. Sinha (1942) working with guinea-pigs observed vasoconstriction with adrenaline, the effect being abolished by ergotamine, and vasoconstriction also by acetylcholine, the effect being abolished by atropine and not enhanced by eserine. Sinha (1942*a*) observed similar effects with adrenaline and acetylcholine in the rat and in the frog (Sinha, 1942*b*). In addition, he also observed dilatation by adrenaline in the frog after ergotamine.

The differences in the response to drugs of the pulmonary vascular system may be explained by the fact that at higher perfusion pressures a larger vascular territory is perfused than at the lower and in such a case naturally the drug action is seen more markedly. Then again, all parts of the vascular territory may not be acted upon by the drugs in the same way and when a longer vascular territory is opened, the result depends on the pharmacological reaction of the part opened.

Apart from the study of vascular responses as a result of nerve stimulation or exhibition of drugs, it was considered necessary to study the effect of drugs on the response of bronchial tubes. Alcock, Berry, Daly and Narayana (1936) investigated the problem using the isolated perfused lungs of the dog first and then the entire animal and introducing drugs into the pulmonary circulation and then into bronchial circulation. For the isolated perfused lung preparation the method of Berry and Daly (1931) was used perfusing simultaneously the pulmonary and the bronchial circulations. When the entire animal was used, it was anaesthetized with ether and intravenous nembutal and with positive pressure artificial respiration, the thorax was opened in the 4th right intercostal space. A cannula was inserted into the posterior bronchial artery to the right lung, which generally arose from the 5th or 6th intercostal artery. Drugs were introduced into the bronchial circulation through this cannula. When it was necessary to introduce the drug into the pulmonary circulation, it was done by injecting the drug into a cannula which was placed in the right auricle and tied there. In the case of isolated lung preparation the tidal air and the perfusion pressures were recorded. In the entire animal, records were taken of the lung movements and blood pressure. It was observed in the above experiments that injection of histamine into the bronchial vascular system caused a diminution of tidal air by constricting the respiratory tracts. This effect was completely released by injecting adrenaline into the bronchial circulation but only partially by injecting adrenaline into the pulmonary circulation. Then again, the histamine effect was much less when it was injected into the pulmonary circulation than when it was injected into the bronchial circulation in similar quantities. How far this phenomenon was due to differences in the drug concentrations reaching the smooth muscle of the respiratory tract or to differences in their site of action remains to be determined.

It is evident, therefore, that the reactions of the bronchomotor and vasomotor apparatus of the lungs depend upon the integrity of the bronchial vascular system. When an adequate bronchial arterial supply is maintained, excitation of the autonomic nerves may produce broncho-constriction, pulmonary vasoconstriction or vasodilatation depending upon the nerve stimulated. If the bronchial artery is cut off, such responses may be cut off or greatly modified.

Just as temporary restriction of blood supply to nerve structures leads to sensory and motor disturbances, it is likely that temporary or permanent depletion of the bronchial arterial supply may be responsible for pulmonary bronchomotor or vasomotor 'attacks'.

Relationship between Physiology and Surgery

Only a few years back it might have been admitted that there was a certain amount of interdependence between medicine and physiology but no one would have thought of connecting surgery with anything but anatomy. We have now begun to realize that physiology must take the help of surgery to solve many of its intricate problems and that surgery cannot make any real advance unless it goes hand in hand with physiology. Operations on animals are essential to investigate the functions of an organ and if surgery is to be considered a science at all, it must be founded upon experiments. Many of the distinguished surgeons in the past have been physiologists as well as surgeons and many of the modern surgeons are equally so. Surgery should be based upon physiology and it could not advance in any other way. Surgery without experiments must stand still and a surgeon has no right to experiment upon the human subject if the lower animals are available for the purpose. While it is true that surgery for its progress must depend upon physiology, it is equally true that progress of physiology depends upon surgery. Without an adequate knowledge of surgery many of the physiological experiments could never be carried out.

Amongst the surgeons who have contributed immensely to the growth of physiology, mention must be made of Lord Lister. Lister, long before he was a surgeon, was an experimental physiologist and he continued to be one throughout his career. He was amongst the first to demonstrate the existence of a dilator pupillae in the iris and to show that, like the sphincter pupillae, the dilator is composed of plain muscle cells. The physiological bias of Lister's mind is also evident by his work on absorption from the intestine and on the flow of chyle from the lacteals, by his researches on the vascular changes accompanying inflammation and by his work on the cutaneous pigmentary system of the frog. It is true Lister's work which revolutionized surgery overshadowed his physiological observations but one is not sure whether he was less proud of his contributions to physiology than to surgery.

Mention must also be made of work of Murphy. Murphy's contributions to surgery were all based on animal experiments and he would not spare himself in carrying out these experiments, sometimes against heavy odds. The contributions to surgery of Victor Horseley or of Harvey Cushing were all the results of patient observations on animals and it was really with their physiological bent of mind that they succeeded in contributing immensely to the advancement of the surgery of one of the most vital organs of the body—the brain. Examples of the value of co-operation between surgery and physiology are many and one can also see that a closer intercourse between

surgery and physiology is essential for the progress of both branches of science.

Emergence of Biochemistry

Though the study of chemical physiology began long ago with experimental physiology, it is only within recent years that biochemistry has been recognized as a separate school of science though still linked with physiology in a number of institutions. Research work in the field of biochemistry is being done extensively all over the world. We owe our knowledge of vitamins to the work of Hopkins at Cambridge. Benjamin Moore at Oxford was also among the pioneers of biochemistry. In most of the universities, biochemistry is on a solid foundation. In India, the biochemical work is progressing on a large scale in most of the laboratories and is fast going ahead of pure physiological work. But I must submit that physiology and biochemistry are so intimately linked together that one is necessarily dependent on the other for making rapid advances.

Concluding Remarks

Having discussed the growth of physiology as an experimental science. it is only proper for me to point out the ways and means whereby this experimental science can grow as rapidly in this country as in others. This can be greatly achieved by placing only such men as teachers in physiology who have competence in experimental work, who work for the sake of work alone and who can devote their full time to the research needs of the department.

An atmosphere of research should be created in the physiological laboratories and the professor in charge should encourage young research workers to take up simple problems and investigate. The band of workers must attack the many problems of human health and disease from the physiological angle, using animal experimentation and human experimentation and all other means that may be available. Apart from research work that have direct bearing on health and disease, purely scientific work must also be undertaken. It must always be remembered that the greatest advance in medicine have been due to researches which had no utilitarian purpose for their immediate object. It is a mistaken policy which demands that all investigations should have a so-called practical import. Many of the most practical applications of physiological principles have resulted from work which was of purely scientific interest and had no practical significance. To cite one example in passing, we may refer to the purely academic work of Pasteur, the value of which to medical science was so brilliantly demonstrated by that world-famous surgeon, Lord Lister. It is, therefore, imperative to

remember that what is purely academic in its scientific import today may be of the most practical significance tomorrow. The results of experiments, however inexplicable at the time, should never be set aside, for all results are based on accurate observations and out of the desire to arrive at the truth and may sooner or later find practical applications in life.

It will also be of very great value if, attached to a department of physiology, a purely research department, called the department of experimental medicine, be created to keep engaged whole-time workers with no administrative and teaching responsibilities. The universities which have funds at their disposal could easily take a move in this direction and allot a substantial amount towards the creation of such a department, paying suitable research scholarships to keen workers who wish to take up research work as a career. The keenness of such workers will be judged only by their sole desire to search into the truth of Nature and not necessarily by possessing high academic distinctions at professional examinations.

I may state with a good deal of pleasure and satisfaction that in the award of university research scholarships and fellowships by the University of Patna, the subject of physiology and experimental medicine is given due recognition at the hands of our popular Vice-Chancellor. I may also reasonably hope that further encouragement and response will be forthcoming.

Let us now drift for a moment to the training of students who are the future research workers. It should be the duty of every teacher of physiology to see that the classes are not merely sterile repetitions by the students of typed instructions to an experimental known result. In order that the student may learn most from his observations, experiments should be chosen which have for that purpose the highest significance. He should be placed as far as possible upon his own resources. He should be required under supervision to make and record his own observations and to draw his own conclusions. The teacher has to keep in mind that the material approach to practical physiology should be the following:

Of what activity is this organ or tissue capable?
What conditions determine its activity?
Does it act in this way when incorporated in the complex of organs which goes to make up the whole organism?
How do modifications in its functioning affect other organs and the whole?

Almost any part of physiology can be intelligently analyzed by these questions. Both the lecture and the practical class can be adapted to this approach. Pure Bernardian physiology is being neglected with the result that our students grow up without wide conceptions of this subject. The field for this skilled work is vast and awaits an expansion.

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SECTION OF PSYCHOLOGY AND EDUCATIONAL SCIENCE

President:—B. L. Atreya, M.A., D.Litt.

Presidential Address

(*Delivered on Jan. 3, 1943*)

SUPERNORMAL FACTORS IN HUMAN PERSONALITY

'There is much in that mysterious being, man, which has yet to be brought into the field of recognition'—Richmond.

Prefatory Remarks

Scientists are generally concerned with problems that are definite and concrete and indeed commonplace. Anything that is out of the ordinary and more or less indefinite in nature, is not likely to receive that amount of attention from them which is given to tangible phenomena. This is the reason why mysteries of hypnotism and dream remained unsolved for such a long time. When Mesmer turned his attention to the phenomena which are now termed hypnotic he was ridiculed by the academic scientists of his age. It is quite probable that in the early stages of investigations of elusive phenomena, many mal-observations will be made and rash theorizing and assertions indulged in. These phenomena thus form fruitful grounds for wild speculations and mysticism. Mystic interpretations are not rare even in such an objective science as Physics. The theory of an all-pervading 'Ether' which is denser than steel and yet allows free movement within it, is akin to a mystic statement. Nevertheless it is a well-known truth that such elusive phenomena when properly investigated have often led to important discoveries in physical sciences. In the domain of Psychology there are phenomena which are still wrapped in mystery and which unfortunately form no man's land as yet. The unconscious was till lately a field of this type. What are popularly known as psychical phenomena point to problems that should legitimately be of interest to the psychologist. The academic psychologists, however, fight shy of these phenomena and psychical research has not yet become a part of scientific psychology. There is no doubt that a good deal of charlatanism and loose observation are to be found in connection

with phenomena of this type. But even when we have made sufficient allowances for deliberate frauds and unintentional fictions, it seems to me there remains an evidence of a type in favour of these phenomena that cannot be roughly brushed aside. Eminent scientists who have made their reputation in different branches of science have testified to the genuineness of such manifestations, and I lay before you today some of the evidences of competent observers in this line of work. It is to be admitted, however, that psychic research has its special methods and pitfalls and it is just likely that even an evidence coming from a reliable scientist may not be really trustworthy. It requires an expert psychologist who knows all the tricks of the mind and who has also made himself familiar with the methods generally employed by 'charlatans' and impostors to produce magical phenomena to be able to judge the genuineness or otherwise of what is called psychic phenomena. I do not pretend to be such an expert. I am free to confess, however, that I have been very much impressed by the available evidence. What I want to stress is that it is up to you as psychologists to consider and investigate in all earnestness, phenomena of the type I shall be describing to you presently, because I think that these phenomena may provide us with clues which may lead to a deeper understanding of human nature. Since my address presents mostly conclusions based on evidence from other sources with the remarks and comments of the observers, some of the statements may appear dogmatic to you in the absence of their proper background. I approach you with the request to face these problems with an impartial attitude and to engage yourself seriously in experiments and observations in this line.

Introduction

Humanity is at present passing through a terrible period, such as perhaps it has never seen before, when all over the world nations and communities are involved in a gigantic war, and have little regard for others' rights, feelings and lives. It is the inevitable consequence of a perverted view of life and a false sense of its values. The world is too much with us. We have pampered our bodies, multiplied our wants and surrounded ourselves with luxuries. In our mad pursuit of worldly gains and bodily comforts we have lost sight of the 'Kingdom of Heaven' which is within us. Our mechanistic civilization is crashing. Humanity is in danger. To avoid disaster a complete change of outlook is essential. Our attention and interest are to be directed into different channels. As Dr. Carrel says, 'Our curiosity must turn aside from its present path, and take another direction. It must leave the physical and the physio-

logical in order to follow the mental and the spiritual.'[1] To quote him further, 'It would be far better to pay more attention to ourselves than to construct faster steamers, more comfortable automobiles, cheaper radios or telescopes'.[2]

But where shall we go for a knowledge of ourselves? It is certainly difficult for persons accustomed to the scientific way of thinking, as most of us here are, to believe in the dogmas of religion or to accept *a priori* arguments of philosophy. Naturally, therefore, our attention turns to Psychology—literally, the Science of the Soul—for enlightenment. But here the eager aspirant of self-knowledge gets bewildered, dissatisfied and disappointed. For, there is no agreement among the psychologists even as to what the subject-matter of their science is and the manner in which it has to be approached. The orthodox scientific psychology is certainly not yet the science of the soul, self or mind. It is still a chapter of materialistic and mechanistic biology; its principal aim is to understand everything mental in terms of the physiology of the brain and the nervous system and the primary biological urges. It avoids all reference to soul, mind or consciousness. For it the human personality is nothing more than a 'reaction mass', 'an individual's total assets and liabilities on the reaction side' (Watson). The upshot of modern scientific psychology, keeping in view the two most influential schools—Behaviorism and Psychoanalysis—may be best put in Joad's words: 'Mind, it seems, is not unique; freedom is an illusion; ethics is a rationalization of non-ethical impulses; purpose and design are figments; living organisms are no less automata than machines'.[3] These conclusions are, however, instinctively repulsive to man, howsoever acceptable they may be to some scientists; he feels that there is much more in him than such a psychology knows. And he seems to be justified to a great extent in view of the facts that have recently come to light. The theories and concepts of the present-day psychology are based upon the reactions and responses of the normal, subnormal and abnormal types of human beings. These scientists naturally fail to comprehend facts which can be rightly called 'supernormal'. Such facts have occurred and been noticed and recorded in all ages.

Recently, however, they have attracted the attention of people trained in the scientific method of observation, record and description. Quite a large number of scientists, highly eminent in their own fields of science—Physics and Chemistry (e g. Sir William Crookes, Sir William Barrett, Sir Oliver Lodge), Biology (Hans Driesch), Physiology (Prof. Richet), Mathematics and Astronomy (Prof. Zöllner), Neurology (Prof. Morselli), Medicine (Prof. Lomroso and Dr. Osty), Surgery (Dr. E. le Bec, Dr. Johnson), Naturology (Sir Wallace), Engineering (Dr. Crawford), Electricity (Marconi) and Psychology (Dr. Gustave Geley and Prof. Baron von Schrenck-Notzing)—have observed

and recorded quite a huge number of facts disquieting for Psychology and Biology. In 1867 the Dialectical Society of London appointed a committee of thirty-three experts to investigate into the nature and occurrence of some alleged supernormal phenomena which defied all scientific explanation, and the majority of the members testified to their genuineness. In 1882 the Society for Psychical Research was established in England, which in course of time opened branches in several countries of Europe and in America, with the following objects:

'1. An examination of the nature and extent of any influence that may be exerted by one mind upon another apart from any generally recognized mode of perception.

'2. To study hypnotism and the forms of the so-called mediumistic trance, with its alleged insensibility to pain; clairvoyance and other allied phenomena.

'3. A critical revision of Reichenbach's researches with certain organizations called sensitive, and an enquiry whether such organizations possess any power of perception beyond a highly exalted sensibility of recognized sensory organs.

'4. A careful investigation of any reports, resting on strong testimony, regarding apparitions at the moment of death, or otherwise, or regarding disturbances in houses reported to be haunted.

'5. An enquiry into the various physical phenomena commonly called spiritualistic; with an attempt to discover their causes and general laws.

'6. The collection and collation of existing materials bearing on these subjects.'

With these objects in view and with a band of well-trained and renowned scientific workers, the Society has been able to gather enormous evidence in favour of various kinds of facts and phenomena which can easily be called supernormal. For psychology it is no longer possible and advisable to disregard and neglect this evidence. In the words of Dr. Konstantin Oesterreich, 'The assertions of eminent investigators—some of them scientists of world-renown—are too numerous and too decided . . . To ignore their combined testimony would be but unscientific, dogmatic prejudice.'[4] It is therefore not proper for psychology, the science of human nature, to proceed with its primary task, namely, to understand the nature of human personality, without taking due cognizance of what this branch of science—called 'Psychical Research', 'Metapsychics', 'Occultism' and 'Psychic Science'—has discovered. Yet two recent publications on the psychology of personality, namely, 'Psychological Foundations of Personality' by Thorpe (1938) and 'Psychology of Personality' by Ross Stagner (1937), have made no reference to any of the facts discovered by psychical research. Hence the justification of my present contention.

The supernormal facts which psychical research has proved beyond doubt and which are of utmost importance to the psychology of personality are too numerous to be referred to in an address like this. Hence I shall select a few types of them.

Miraculous Cures and Supernormal Control over the Body

If thought were merely a function of the brain, and mental life, on the whole, that of the entire nervous system, as some people take for granted, thoughts and emotions would not have any actual efficacy in influencing the body and its organs. It is, on the contrary, found by careful observation and experimentation, that thoughts and emotions have great effects on the body and its organs. Dr. Cannon's recent experiments on emotions and their chemical effects on the autonomic nervous system are too well known to psychologists to be mentioned here. Dr. Forbes Winslow noted long ago 'That alteration of tissues have been the result of a morbid concentration of the attention to particular organic structures'.[5] Healthy imagination and pleasant emotions, on the other hand, according to Tuckey, 'bring about a good state of the blood and secretions, and improve health'.[6] Suggestion has recently been discovered to be as effective as medicines; perhaps even much more. 'By means of suggestion,' says Dr. Emile Coué from his extensive experience, 'one can stop haemorrhage, cure constipation, cause fibrous tumours to disappear, cure paralysis, tubercular lesions, varicose ulcers, etc.'[7] Referring to M. Gibert's effective treatment of warts which were too numerous on the backs of the hands of a boy to leave any free space, by mere suggestion, F. W. H. Myers and Dr. A. T. Myers wrote in a paper, 'Mind Cure, Faith Cure, and the Miracles of "Lourdes",' in the *Proceedings*, S.P.R., 'This bold experiment illustrates the effect that the mind when duly stimulated may in some cases have upon morbid conditions of the body which medical and surgical science is puzzled now to relieve.'[8]

That suggestion is most effective in producing changes in the body and curing functional as well as organic disorders of the body and even in bringing about insensibility to pain in hypnotic subjects is sufficiently well known now. The well-known cures effected by M. Coué, Bernheim and Charcot are a very strong evidence of this fact. According to Alexander Cannon, 'Hypnosis *can* relieve pain in pleurisy, sciatica, lumbago, neuralgia, encephalalgia, cancer, tabes dorsalis, and even gastric ulcers, duodenal ulcers, and appendicitis, etc.'.[9] He further says, 'Hypnotic treatment is also itself useful in the treatment of tetanus, and other spasmodic diseases . . . The dysuria of Bright's disease, or diabetes, stricture, and even prostratic enlargement in some cases, can be relieved by hypnotism. Childbirth can be made painless. The menses can not only be regulated, but if absent, frequently brought on'.[10] Dr. James Esdaile, who was a surgeon at Calcutta in the middle of the last century, has left a record of no less than 250 surgical operations under anaesthesia brought about by hypnotic suggestion.

Cures effected by prayer or *mantra*, sometimes even from a long distance, are even more marvellous, verging on the miraculous, than those effected by auto- or hetero-suggestion. Dr. Alexis Carrel, a great authority on medical science, writes, 'Our present conception of influence of prayer upon pathological lesions is based upon the observation of the patients who have been cured almost instantaneously of various affections, such as peritoneal tuberculosis, cold abscesses, osteitis, suppurating wounds, lupus, cancer, etc. . . . . The miracle is chiefly characterized by an extreme acceleration of the process of organic repair . . . The only condition indispensable to the occurrence is prayer. But there is no need for the patient himself to pray . . . It is sufficient that someone around him be in a state of prayer'.[11] A very interesting and detailed account of such cures, actually effected at Lourdes in Belgium, is given in 'Medical Proofs of the Miraculous' by Dr. E. le Bec. The author, who was a surgeon to St. Joseph's Hospital at Paris, has referred to eleven very serious cases treated miraculously at Lourdes, most of which could not be treated by the best available surgeons and physicians. They were cases of varicose veins of severe nature, suppurating fracture of the leg, non-suppurating fracture of the thigh, Pott's disease, severe ulcer of the leg, lupus of the mouth, club feet, peritoneal tuberculosis with fistulae, intestinal perforations, all occurring together, epithelial cancer, and pulmonary tuberculosis with cavitation. All those cures are said to have taken almost negligible time and were not at all followed by any period of convalescence. I have seen with my own eyes cases of extremely painful scorpion-sting, where all available medicines had failed to relieve the patient of the pain, cured within a few minutes by *mantra*.

Ordinarily, human beings have under their control only the voluntary muscles of the body; the autonomic nervous system and the organs controlled by it are beyond the control of human will. But there are people in India and other countries, who by undergoing some training are able to command even their organs of respiration, digestion and circulation, etc., which are not normally under the control of man. Last year I had an occasion to examine a *yogi* who marvellously controlled his pulse-rate at will and made it vary in the two hands, lowering, accelerating and stopping it at times. He brought his heart to complete rest for a few seconds, which the medical doctors, invited to test him, testified. He dislocated the bones of his right shoulder and left wrist, and challenged the doctors to set them right, which they failed to do. But he set them right in a moment. Such feats of supernormal control over the body were also shown by three Egyptian fakirs, the Bey brothers, in 1900 at the Paris Exhibition, who could 'at will alter the rate of pulsation in various parts of the body, and make all these 'pulses' totally different from the rate of the heart-beat'.[12]

Rahman Bey could even go so far as to suspend his animation and heart-beat for a considerable length of time and be in a state of complete bodily catalepsy, in which he could even be temporarily buried. In 1927, Hereward Carrington witnessed the burial of Hamid Bey in such a cataleptic state for three hours in Englewood, N.J., on January 28. It is nothing in comparison to what I myself witnessed last year, when a *yogi* was in a voluntary state of suspended animation ('samádhi') for full six months. I have seen and examined another *yogi* who suspended his respiration for one hour and twenty-five minutes in my presence. A case of another *yogi* who suspended animation for fourteen hours was published in the *Leader* (Allahabad) of September 8, 1938. Yoga practices often make people immune to the chemical effects of harmful substances. It was reported in the *Leader* of September 20, 1938, about Mr. S. L. Rao, Principal, Yogic Ashram, Bangalore, that while giving a demonstration of his powers, 'He drank almost an ounce of strong sulphuric acid and fuming strong concentrated nitric acid. He took a quantity of nitric acid in the hollow of his hand, which was altogether unaffected by the action of the acid. But as soon as a copper piece was dropped in the acid, still held in the hand, it had action upon the copper'.

It is not only the physiological and chemical functions and qualities of the body that can be brought under one's control, as appears from the instances quoted above, but some marked changes can also be brought about in its physical properties, such as weight, as appears from the phenomenon of 'Self-levitation', or simply 'Levitation' as it is called. I know a *yogi*, now dead, who was capable of rising up and keeping him suspended in empty space. In a paper read at the Third International Psychical Congress held in Paris in 1927, Prof. Schrenck-Notzing described the case of a young man who demonstrated his power of self-levitation, acquired through the practices of breath-control, no less than twenty-seven times. Some of the famous mediums, D. D. Home, Eusapia Palladino, and Stainton Moses, were naturally gifted with this power. The levitations of D. D. Home are described in 'Researches in Spiritualism' of Sir William Crookes and in 'Experiences in Spiritualism' of the Earl of Dunraven, and those of Eusapia Palladino in Lombroso's 'After Death—What?'. Hereward Carrington observed a levitation of Eusapia Palladino under good laboratory conditions, where a loss of weight from her body was mechanically registered. He says, 'However incredible such phenomena may appear, there can hardly be any doubt that genuine levitations have occurred'.[13] According to Captain V. D'Auvergne, the Lamas of Tibet even now know the science and art of 'neutralization of gravity'.[14]

Exteriorization of Motivity and Telekinetic Phenomena

French investigators, in particular, have made a large number of experiments on the existence, nature and use of what some of them have called the 'Magnetic fluid', something like a vital energy supposed to be present in the human body. It can, according to them, be sent out of the body at will and even unconsciously, and can bring about some movement or action at a distance from the body. Some of them have devised some very fine and complicated instruments—such as the 'dynamoscope', the 'bioscope', the 'magnetometer', the 'galvanometer', the 'biometer', and the 'sthenometer'—by which this vital energy could be detected and recorded. Col. Albert de Rochas, the author of 'L' Exteriorization de la Motoricité', takes 'exteriorization of motivity' as fully established on the basis of his observations and experiments on the phenomena produced by Eusapia Palladino, the famous Italian medium. According to Emile Boirac also, 'There exists a great number of facts in which a human organism appears to exert upon another organism an influence where suggestion is certainly excluded and which strangely resembles a radiation at a distance'.[15] Hereward Carrington also says, 'It is certain that some form of energy is radiated from the body, moving matter or affecting instruments devised for its registration'.[16]

This radiant vital energy, sometimes called 'human fluid', has been found by Drs. L. Clarac and B. Llaguet of Bordeaux, in the case of 'Mme. X' to produce wonderful effect on organic tissues of objects. Having made experiments on plants, flowers, wine, molluscs, fish and blood, etc., they came to the conclusion that the liquefaction of the tissues and decomposition of objects and dead bodies ceased, never to return again, when she placed her hand on or over them for some time. This corroborates the observations of Dr. Louis Favre on Mme. Agnes Schloemer, the imposition of whose hands tended to destroy the germs of diseases; even the *bacillus subtilis* and *bacillus anthracis*. Dr. Durville also had seen the bacillus of typhoid fever being destroyed under the influence of Mme. Schloemer's hand, a report of which he published in the 'Bulletin' of the General Psychological Institute of Paris.

The term *Telekinesis* stands for 'the supernormal movements of objects at a distance, in the absence of any known force or energy moving them'. Another term *Parakinesis* is sometimes used for movements not explicable by normal process, although there is some contact of the medium with the object, such as happens in levitations of tables when the medium's hands are placed over the surface of the table merely touching it. Both these kinds of movements are to be distinguished from those seemingly supernormal movements which can be explained as an effect of 'unconscious muscular action', which is the only explana-

tion known to normal psychology. Both the spontaneous and the experimental evidence gathered in recent years go in favour of telekinesis and parakinesis being regarded as facts. Ample evidence of these has been found in the seances given by Eusapia Palladino, which were first witnessed by a Committee of French Scientists appointed by the Psychological Institute of Paris, which, on the whole, was satisfied by the evidence in favour of telekinesis. The same medium gave successful telekinetic seances in 1894 on the island of Rouboud under extremely controlled conditions in the presence of a few selected investigators, namely, Prof. Richet, F. W. H. Myers, Sir Oliver Lodge and Dr. Ochorowicz. Dr. Ochorowicz himself has recorded very remarkable observations of telekinesis exercised by a young non-professional girl, Stanislawa Tomczyk of Warsaw under extremely controlled conditions and in good light. Sir William Crookes also observed many telekinetic phenomena happening in the presence of the famous medium, D. D. Home. Hereward Carrington observed many telekinetic phenomena in the presence of Eusapia Palladino and came to the conclusion: 'We have convincing evidence, it seems to me, that in the case of Eusapia Palladino, physical objects were repeatedly moved as the direct result of the medium having willed their movement . . . I took every conceivable precaution, and tried every available test to assure myself and the others present, that no physical contact existed'.[17]

The usual assumption made by psychical researchers in connection with telekinetic phenomena is 'that some physico-biological energy is employed, generated within the medium's organism, and exteriorized from it into space. This must, somehow become solidified, so to say, in order to affect matter'.[18] Dr. Crawford, a lecturer in mechanical engineering at Belfast, did actually discover some such thing, which he called *teleplasm*, coming out of the body of Miss Katheleen Goligher, a medium on whom he made many valuable observations with regard to *Levitation*, supernormal lifting of objects. He could, in fact, succeed in actually taking a number of flash-light photographs of this teleplasm.

Raps or 'percussive' sounds on walls, doors, floors, tables and other articles of furniture, were first noted by the well-known Fox sisters in Hydesville, New York, in 1847-48. Later on they were mechanically recorded by Sir William Crookes in the presence of the famous medium, D. D. Home, and by other investigators in the presence of Eusapia Palladino. They were explained by the Palladino-investigators in terms of sudden exteriorization of nervous energy from the body of the medium. The mere occurrence of raps is not the only supernormality about them. Very often they indicate behind them some sort of 'intelligence' or 'personality' other than that of the medium or of the hearer, which seems to make use of them as symbols of

expression of some ideas or messages. Dr. J. Maxwell has made a special study of this aspect of raps. According to him, 'Not only do the raps reveal themselves as the productions of intelligent action, they also manifest intelligence in response to any particular rhythm or code which might be suggested'.[19]

Poltergeists: The phenomena known as poltergeists are quite common in India. I know some very genuine cases. In these cases various kinds of disturbances are created in the presence of some individual by some unknown agency, such as throwing about the furniture of a room, breaking of crockery, besmearing the walls with blood, placing flesh, blood or bones among articles of food, throwing filth in the kitchen, hurling stones in the courtyard of the house, making disturbing raps and confused noise, ringing the bells, and doing many such other things as may annoy the family. Dr. Harry Price, the Research Director of the British National Laboratory for Psychical Research studied in 1926 a very interesting and genuine case of a poltergeistic medium, Eleonore Zugum, a report of which was published in the *Proceedings* of the Laboratory, Part I. Other cases are described in the *Proceedings*, S.P.R.[20] At the present stage of our knowledge it is very difficult to arrive at any satisfactory explanation of these phenomena even in terms of exteriorization of some energy from a medium's body, which is the only alternative explanation to that of an angry and noisy spirit doing the mischief, in case the facts are not due to fraud or trickery.

Apparitions

Ghosts, apparitions and phantasms are known to humanity since time immemorial. A scientific approach to them, however, began with the inception of the Society for Psychical Research in 1882. The Society has since been able to gather authentic evidence of enormous strength in favour of apparitions being something more than mere illusions and hallucinations of the percipients' minds. This enquiry has further revealed a very strange fact that there are apparitions not only of the persons who are already *dead* but also of the persons who are *dying* and even of those who are actually *living*. Stranger even is the fact that apparitions can be experimentally produced at will by the living persons. Apparitions of all these classes have been found to be real, objective and perceptible. As Carrington says, 'Literally thousands of such cases are on record. These are first-hand, well-attested and documented'.[21] In the words of Andrew Lang, 'Only one thing is certain about apparitions, namely, that they do appear. They are really perceived'.[22]

One example of each class of apparitions may be given here: (1) An *apparition of the dead*: A gentleman, while awake in his bed, saw his old brother officer dressed in khaki, with pale face, bidding him adieu. When accosted, he said: 'I am

shot'. Asked where, he replied, 'Through the lungs'. When further questioned, the figure vanished. The percipient was not dreaming, but fully awake; looking at the clock, he saw it was 4-10 a.m. Two days later he received the news that the officer had been killed on the night in question between 11 and 12.[23] (2) An *apparition of the dying*: While sitting in her room, engaged in knitting or sewing, a woman saw very distinctly and clearly her brother, who was living at a distance of about 25 miles in a village, standing before her and bidding her adieu. The apparition disappeared very quickly. But after a day or two the woman received the news that her brother had died exactly at the same time when she had seen the phantasm.[24] (3) An *apparition of the living*: Major-General Richardson, a military officer of the British Government in India, was wounded at the time of the siege of Multan, on September 9, 1848, and thinking that he might not survive, he said to somebody by his side, 'Take this ring off my finger, and send it to my wife'. Exactly at the same time, Lady Richardson, who was 150 miles away at Ferozepur, saw an apparition of her husband in a wounded condition and heard it saying exactly the same thing. This fact was recorded by the lady and was later on verified by the husband after his recovery.[25] (4) An *experimental apparition*: S. H. B., an agent of the S.P.R., wishing to test the alleged power of self-projection, determined to be present in the bedroom of two lady acquaintances of his living at a distance of three miles, at one o'clock. Having willed so, he went to sleep and did not think of it any more. Five days afterwards he went to see the ladies, and was surprised that without his own mention of anything, the elder of the two ladies told him that five days ago she had been very much frightened by actually perceiving him standing by her bedside at an odd hour of one o'clock at night. She avowed that she was fully awake at the time.[26]

Apparitions of the living are generally found coincidental with a state of sleep, serious illness, some great crisis, hypnosis or trance experienced by the person whose apparition is seen. This phenomenon is variously known as dream-travelling, psychic excursion, psychic invasion, self-projection and psychorrhagic diathesis. From thousands of such cases F. W. H. Myers came to the conclusion that the subliminal mind of man—the deeper layer of human personality—has an inherent power of 'self-projection' which expresses itself in these phenomena. He writes, 'This self-projection is the one definite act which, it seems, as though a man might perform equally well before and after bodily death'.[27] This self-projection seems to be a species of thought-transmission or telepathy, in which, it seems, the thought of oneself is projected out in and through space. But then, are thoughts capable of existing outside an individual's brain or mind? Are they perceptible as things in the objective world? Do they persist there for an appreciable time? Yes!

there are well-examined facts which have made psychic investigators think so. Prof. Darget, Dr. Geley and Dr. Joire are among them. In the words of Dr. Lindsay Johnson, 'Thoughts are objective things, which can be seen and heard, or else photographed on a sensitive plate . . . like any ordinary visible object, and can be projected to a distance, and persist or reappear after an indefinite time'.[28] Recent investigations have revealed the existence of an 'Astral Body' which throws a still greater light on the problem of apparitions than mere thought-transmission or self-projection, as Hereward Carrington says, 'Many of these cases strongly suggest that more than mere thought-transference was at work—that some "astral body" actually manifested its presence and was seen by the percipient at the time'.[29]

The Aura and the Astral Body

The human aura: Scientific investigation into the existence and nature of the human aura was long ago begun by Baron von Reichenbach who published his pioneer work in 1848. He began to make observations on magnets and discovered that they emitted a semi-luminous vapour-like something which was visible in the dark to certain sensitive persons. An enormous number of experiments conducted by him convinced him of the fact that human bodies also emit a magnetic energy of this nature, which appeared like a 'flame' emanating from the body and was seen by especially gifted individuals, called 'sensitives' by Reichenbach. It was not open to the normal vision of the ordinary man. The emanation was called 'aura'. In 1874 Francis Gerry Fairfield published a work, 'Ten Years with Spiritual Mediums', in which he refers to his carefully conducted researches into human aura. 'These data,' he says, 'support the hypothesis that all nervous organisms emit an ethereal aura susceptible of control by consciousness, of transmission in a given direction at the will of the organism, and of translation into physical phenomena under given conditions.' Further valuable research work in this direction was carried out by Dr. Walter J. Kilner, electrician to St. Thomas Hospital, London, which is embodied in his work, 'The Human Atmosphere'. Dr. Kilner claims to have established the existence of the aura by means of certain chemically prepared screens through which even a normal man could observe it surrounding the human body. The aura, according to Dr. Kilner, was not visible to the ordinary human eye on account of the wave-length of its light being beyond the visible spectrum. He has described in his book the structure of the aura in minute details, for which there is no place here. 'At death,' according to Dr. Kilner's observations, 'the aura gradually shrinks, and there is no aura at all surrounding a corpse.' Hereward Carrington also made some experimental observation in this connection on the basis of which he says,

'There is much evidence that such an aura exists, which is not due to any subjective impressions, or optical effects'.[30] More recent investigations at Moscow under Prof. Tchijewsky at the Central Laboratory for Electro-biological Research and under Prof. d'Arsonval, Prof. Lapicque and many others in France and Germany, have further established that the human aura is electrical in nature.

Still finer and more psychic in nature is the *Astral Body*, on which too a great deal of scientific investigation has been conducted in recent years. The pioneer workers in this field were Col. de Rochas, Dr. Baraduc, M. Hector Durville, M. Charles Lancelin of France and Drs. Matla and Zaalberg van Zelst of Holland. Durville's 'Le Phantome des Vivants' and Lancelin's 'Méthode de Dédoublement Personnel' are the two earliest standard works on the subject. These investigators have done great scientific work in establishing the reality and objectivity of the astral body as something different and separable from the physical. M. Durville placed large calcium sulphide screens at some distance from the entranced subject, and requested the astral body to approach them. As it did, so he reports, the screen in question glowed up with added brilliance. Drs. Matla and Zaalberg van Zelst, the Dutch physicists, made very remarkable efforts by experimental and mechanical means to determine the physical properties of the astral body, and arrived at certain definite conclusions. They invented a complicated machine, called by them, the 'dynamistograph', by means of which they claim to have come into direct communication with the astral bodies, without the aid of any mediums. Their conclusions with regard to the weight of the astral body were closely borne out by the experiments conducted in this connection later on by Dr. Duncan McDougall of Haverhill, Mass., in which he determined the weight of the astral body by weighing a number of patients, before and immediately after the moment of their death, in a very clever and ingenious manner. At death they all lost a weight between 2 and 2½ oz.

The astral body, according to these and other investigators, is a psychic double, which, although very fine and light in structure, is of the same size and form as the physical. It is capable of all sensory and motor powers, in a much greater degree of which the physical body is. During the waking state of the human personality it coincides, as it were, with the physical body. During sleep, however, certain detachment occurs between the two. The same happens when one faints or becomes unconscious on account of some other cause. Dream-travelling and 'going to' suggested places in deep hypnotic trance, of which there are several well-examined and verified cases on record, are effected through the agency of this body. It can also be detached from the physical body experimentally by putting a person to deep hypnotic or 'magnetic' sleep, and

even voluntarily when one has acquired conscious power to do so through some practical course of training. In all such detachments there persists some link between the astral and the physical bodies, on account of which the former does not get fully severed from the latter, as it happens at death, and returns instantaneously whenever required. There is an interesting case of Dr. Wiltze, described in the *Proceedings*, S.P.R.,[31] who when 'in extremis' is seen by himself leaving his physical body with which he remained connected by a 'silver cord' and returning to it after some time. The astral body has been sometimes observed by friends and relatives of the dying person leaving the physical body. Such cases are mentioned and described at length in the 'Journal of S.P.R.'[32]

Recently Sylvan J. Muldoon and Hereward Carrington have brought out a very interesting work, 'The Projection of the Astral Body', in which they have outlined the method by which the astral body can be voluntarily projected out of the physical. They contend that it can be projected and sent out at will to any place or person at any distance with a view to carry some message, to bring some information, or to appear to some one as an apparition. In such projected states the astral body retains the personal consciousness, which it often does not in dream-travelling or in psychic excursions in deep hypnotic trance, and exercises its sensory and motor functions, often even more effectively than it does in the waking state when its powers are limited by the physical body, time and space. There are authentic cases when the projected and sent out astral body has been observed by persons concerned. The self-conscious astral double of a person can perceive his physical body lying unconscious in the bed, chair, or in the entranced posture. As it has already been pointed out, it is the astral body that may give rise to the phenomena of ghosts, apparitions and haunted houses.

Supernormal Cognition

The vast majority of mankind, unsophisticated by materialistic and mechanistic theories of knowledge, held by modern psychology, has always believed in the possibility of knowledge free from the limitations of senses, time and space. In every age, country, or town there have been and are some people who are alleged to be possessing the capacity of supernormal cognition and almost every person has at least once in his life come across some such incident as he cannot easily explain in terms of the psychological theory of knowledge. Since the foundation of the Society for Psychical Research, however, a systematic and scientific study of all types of supernormal knowledge has been made on an extensive scale. The investigators have collected a large number of facts in this connection, and have coined several new terms to describe them. Prof.

Richet used the term 'Cryptesthesia' to indicate all sorts of supernormal cognition. Recently Dr. J. B. Rhine has used the term 'Extra-sensory Perception' also to cover almost all types of supernormal cognition. F. W. H. Myers used 'Telepathy' for 'communication of impressions of any kind from one mind to another independently of the recognized channels of sense'. The terms 'Lucidity', 'Clairvoyance' (including 'Clairaudience'), 'Second Sight', and 'Extra-sensory Perception' (in a literal and restricted sense) are used for perception of things and events happening in the present, near or far off, without the use of the sense-organs. It is called 'Retrocognition' when the past—sometimes long past—events are perceived as if they are occurring at present, and when the knowledge cannot be explained in terms of memory. It is called 'Precognition', 'Premonition', 'Foreknowledge' or 'Prophecy' when the impending future events are perceived in the present, and the knowledge is not based on mere inference or surmise. It is called 'Psychometry', when a person is able to describe the past history of an object, or events and incidents connected therewith, simply by handling it. Telepathy is called 'Mind-reading' or 'Thought-reading' when a person can directly know and describe the contents of the mind of another, and 'Thought-transference' or 'Thought-transmission' when one can, at will, send his ideas to a desired person without the use or aid of any physical or physiological mechanism, and without being at all affected by distance.

The fact of supernormal cognition of almost all of the above-mentioned types has been accepted and proved beyond doubt by all psychical researchers. I shall quote some of the most eminent authorities. The well-known psychologist, William McDougall, has said, 'In my view the evidence for telepathy is very strong.'[33] Hans Driesch, the famous German biologist, writes, 'We have spontaneous telepathy as a quite certain fundamental phenomenon.... Quite certainly established further is thought-reading... Psychometry ... is, *prima facie*, a fact ... Prophecy ... I will describe as probable'.[34] Prof. Richet, the eminent physiologist of France, writes, 'Telepathic lucidity certainly exists; it has been proved by numerous experiments.'[35] 'There is a strange faculty of cognition in human beings that brings information which could not be acquired by the normal senses.'[36] 'Premonition is a demonstrated fact.'[37] 'This faculty of cryptesthesia is not limited by time and space.'[38] Hereward Carrington, who has devoted about forty years to psychical research, says, 'The fact of telepathy must be granted. We may now regard it as so thoroughly established that no question whatever exists as to its occurrence. Possibly it occurs far more frequently than we know.'[39] Tyrrell, another great scientific investigator, says, 'I should myself regard the following points as established: There is a faculty of extra-sensory perception which manifests itself in the modes of

telepathy, clairvoyance and precognition, and probably the fourth mode of retrocognition. The evidence for the existence of extra-sensory faculty rests upon three bases of spontaneous experimental and trance-phenomena. The evidence cannot be reasonably explained by means of any normal hypothesis, or by a combination of normal hypotheses'.[40] Even Dr. Sigmund Freud, the father of psychoanalysis, has admitted, 'Taking all the events together, there remains a heavy weight of probability in favour of the reality of thought-transference'.[41]

It is impossible for me to refer here to the actual evidence which has convinced psychical researchers of the reality and operation of supernormal cognition in human life. It is too enormous to be summarized in such a short time as I have at my disposal.[42] I shall, therefore, completely ignore the spontaneous cases, and shall refer to some experimental work that has recently been done in connection with telepathy, extra-sensory perception and other forms of supernormal cognition. In 1881-82 a group of investigators, which included Prof. William Barrett, Mrs. Sidgwick, Prof. Balfour Stewart and Prof. Alfred Hopkinson, made successful experiments on telepathy with the children of Rev. A. M. Creery of Buxton, in which numbers, words and playing cards were used. In 1883–85 Mr. Malcolm Guthrie of Liverpool and Mr. J. Birchall, Honorary Secretary of the Liverpool Literary and Philosophical Society, conducted a long series of experiments, some of which were attended by Sir Oliver Lodge, in which drawings, imaginary scenes, and sensations of taste and pain were successfully transmitted. In 1885-86 Prof. Pierre Janet conducted experiments on telepathically hypnotizing his distant subject 'Leonie'. In 1889-90 Professor and Mrs. Sidgwick and Mr. G. A. Smith conducted successful experiments in thought-transference with a subject in the hypnotized state. In the same years Dr. Alfred Backman of Kalmar in Sweden made successful experiments with hypnotized subjects who were given suggestions to 'go to' certain places and to bring information as to what was happening there at that time. In 1892 Dr. A. Blair Thaw of New York conducted a series of successful experiments in telepathy with his wife as the percipient. From 1890 to 1895 Mrs. Verall carried out successful experiments in thought-transference with playing cards, with her daughter sometimes acting as percipient. In 1892 Miss Despard and Miss Campbell made very successful experiments in transmitting thought at great distances. In 1905 Miss Clarissa Miles and Miss Hermione Ramsden made very successful experiments in thought-transference at a distance of 400 miles. Between 1910 and 1915 Dr. Gilbert Murray carried out a series of experiments in telepathy, which proved very successful. From 1912 to 1921 Dr. Rudolf Tischner of Germany conducted very careful experiments in telepathy and clairvoyance and published his results in his well-known work, 'Telepathy and Clairvoyance'.

In 1828-29 Upton Sinclair carried out a series of successful experiments in telepathy with drawings, in which his own wife acted as percipient. They are described in his work, 'Mental Radio, How to Use It?' From 1921 to 1934 Rene Warcollier, a French chemical engineer, carried out a large number of experiments in telepathy, which he has described in his work, 'Experiments in Telepathy'.

The most remarkable and extremely convincing experiments in clairvoyance were made in connection with M. Stefan Ossoweicki, an amateur clairvoyant of Poland. In 1923 Eric J. Dingwall, a research officer of the British Society for Psychical Research, tested him in successfully reading the contents of a slip of paper enclosed in several envelopes, one inside the other, sealed and guarded satisfactorily.[43] The same medium was again tested almost in the same manner in 1933 by Theodore Besterman, the then research officer of the Society, and was found extremely successful in revealing the concealed contents. A very interesting case of a boy, Benito Paz, who was described as 'The Child with Roentgen-Ray Eyes', appeared in the *Medical World* for May 10, 1929. He was examined by several medical men who were satisfied that he could clearly see and describe objects placed in metal cases, read letters enclosed in three or four covers, and name objects inside the pockets of men.

In very recent years some very remarkable and convincing experiments on extra-sensory perception have been conducted under very strict laboratory conditions and evaluated by statistical and mathematical methods. Two of such series of experiments may be referred to here. From 1930 to 1934 Dr. J. B. Rhine, Associate Professor of Psychology in the Duke University, Durham, North Carolina, carried out a series of such experiments and came to the conclusion that 'extra-sensory perception is an actual and demonstrable occurrence'.[44] G. N. M. Tyrrell of England carried out further experiments on extra-sensory perception under still more strict laboratory conditions and with the help of several elaborate mechanical arrangements and with his newly invented 'Pointer Apparatus' and 'Electrical Apparatus'. He came to the conclusion that 'extra-sensory perception is an unquestionable fact'.[45] More recently Whately Carington and S. G. Soal have verified the results of Rhine and Tyrrell by their own ingenious methods of investigation and have established extra-sensory perception beyond doubt. A summary statement of their experimental work with Introduction by Prof. C. D. Broad has appeared in the *Proceedings*, S.P.R. for June, 1940.

According to the recent investigations conducted statistically on a mass-scale and evaluated mathematically, it appears that telepathy and extra-sensory perception are not powers of a few privileged individuals. They seem to be potentially present in all human beings and begin to function under some hitherto

undetermined conditions. According to Rhine, 'Extra-sensory perception occurs and may be demonstrated in many normal people in undeniable fashion'.[46] So does Warcollier write about telepathy, 'I believe, it occurs constantly and continuously among *all* living beings, asleep or awake'.[47]

Well-attested and verified cases of *Precognition* are described in Mrs. Henry Sidgwick's paper 'On the Evidence of Premonitions' in the *Proceedings*, S.P.R.[48]; in Saltmarsh's *Foreknowledge*; in Prof. Richet's *L'Avenir et la Premonition*; in Dame Edith Lyttleton's *Some Cases of Prediction*; in Ernest Bozzano's *Des Phenomenese Premonitoires*; in F.W.H. Myers's paper 'Retrocognition and Precognition' in the *Proceedings*, S.P.R.[49]; in Maurice Maeterlinck's *The Unknown Guest*; and in Eugène Osty's *La Connoissance Supranormale.* According to Saltmarsh, there is on premonition 'a mass of evidence too weighty to be set aside'.[50] According to Carrington, 'Premonitions seem to be, at times, exceedingly well evidenced and circumstantial'.[51] Dunne, in his well-known work, 'An Experiment with Time', holds that precognitive dreams are as common as dreams of the past events.

The most remarkable case of *Retrocognition* is that of two ladies, Miss Anne Moberley and Miss E. F. Jourdain, described by them in 'An Adventure', wherein they state that on various occasions in the years 1901, 1902, 1904, and 1908 they felt and experienced that they were moving in the gardens of Versailles at the time of Marie Antoinette, about the year 1780. There is another interesting case described by Miss X in her 'Essays in Psychical Research'. Rosemary, an English girl, has described very correctly the historical events and personalities of the ancient Egypt, as it appears from the book, 'After Thirty Centuries', by Howard Wood.

Mrs. Piper, the well-known American medium, was highly capable of 'Psychometry', in her trances, as it appears from a *Report* about her published by Mrs. Henry Sidgwick in the *Proceedings*, S.P.R.[52] Dr. Eugène Osty refers to quite a large number of cases of psychometry in his valuable work, 'Supernormal Faculties of Man'. One such case is that of Mme. Morel who was capable of reading the characteristics of persons through objects that were in contact with them. The lady could describe even the events which happened to the owner of an object after he had parted with it. Prof. William Denton's book, 'The Soul of Things', is a good record of his experiments on psychometry with his wife and sister as mediums. Many other cases are described in the *Proceedings*, S.P.R., Vols. XV and XVI.

Crystal-gazing, Automatic Writing and Automatic Speech

Supernormal cognition is often revealed in what are known as Crystal-gazing, Automatic Writing and Automatic Speech.

In *Crystal-gazing* the person fixes his eyes on a bright and shining surface of a crystal, a glass-ball, a pot of water, a saucer of ink, or any other bright object with a dark background. After a little concentration of attention and lapse of the normal consciousness the crystal-gazer begins to see images, figures, persons, events or scenes on the surface of the article used. A thorough investigation into crystal-gazing has revealed that besides the memories and imaginations of the seer, which can be easily explained in terms of normal and abnormal psychology, the visions of the crystal-gazer include: (i) images of what at some time or other of his life was observed by the seer quite unconsciously; (ii) images or ideas acquired from other minds through subconscious telepathy; and (iii) images of future events or prophetic visions. Instances of each class are quoted in Miss X's 'Essays in Psychical Research'.

In *Automatic Writing* the writer, keeping aloof his personal consciousness, simply allows his hand and the instrument (a planchette, an ouija board, or simply a pencil) held in it or simply touched by it to move quite automatically and freely. Sometimes quite strange and unexpected messages and answers are written, which often purport to be coming from some supernormal sources, such as the departed spirits. Automatic writings include pictures, drawings, sketches, paintings, etc. There would have been nothing strange about automatic writing in the light of what we now know about the unconscious mind through psychoanalysis, had it not sometimes revealed *contents* which had never been consciously or subconsciously experienced by the writer in his life and which prove to be *veridical* and indicative of the *personal identity* of some deceased person. One very remarkable case of automatic writing, investigated by Dr. Hyslop, is known as the 'Thompson-Gifford Case'.[53]

Almost the same may be said *mutatis mutandis* of *Automatic Speech*, of which there are very interesting and mysterious cases in which 'languages quite unknown to the medium are occasionally spoken'.[54] .The cases of Mrs. Curran, who, living in modern times, could automatically produce splendid literary works 'in a sort of late Medieval English', and of Miss Rosemary, who was heard speaking for the first time in this age the dead and extinct ancient Egyptian language, may be mentioned. The former is described in Dr. Walter Franklin Price's 'The Case of Patience Worth' and the latter in 'Ancient Egypt Speaks' by A. J. Howard Hulme and Frederic H. Wood.

Dowsing

A special variety of supernormal cognition is known as *Dowsing*, which means divining of the presence of a water-spring underneath the earth for the purpose of digging a well. This knowledge is generally obtained through the movements of a

V-shaped twig, the two ends of which the dowser holds in his hands, while moving along the surface where water is to be sought for. The twig begins to shake violently when the person happens to stand on the place beneath which water exists. Sometimes other means are also used by the dowser than the V-shaped twig, and other things than water, such as oil and minerals, are also discovered. Sufficient investigation has been made in connection with this mysterious phenomenon. Sir William Barrett published two long reports on the subject in the *Proceedings*, S.P.R.[55] Many scientific committees have been appointed to investigate into its truth, and they have all been convinced of its genuineness. In the words of Hereward Carrington, 'The genuineness and actuality of dowsing can no longer be questioned by any one familiar with the facts'.[56] A very interesting case of dowsing done by Sapper Kelly during the Gallipoli campaign in the last war has been described by Ralph Shirley in the *Occult Review* of August, 1916.

How the dowser's twig, called the divining rod, or any other instrument used by him for the purpose, gets affected by the water underneath, is a mystery not yet solved. All explanations in terms of physics and physiology, such as radio-activity, electric currents and biological radiations, etc., are unsatisfactory.[57] Sir William Barrett seems to be right in thinking that the knowledge of water is got by the dowser through subconscious clairvoyance and is communicated to the rod through unconscious muscular activity.

Genius

The 'Flash' or 'Inspiration' of Genius—when some ready-made solution of an extremely difficult and baffling problem, new and quite original ideas and plans, finished products of highly intellectual processes, highly complex artistic compositions or constructions, or previously unlearnt modes of response, happen to rush into the consciousness of a person otherwise known to be of average or even subnormal parts, quite spontaneously and with lightning speed—is a clear indication that some deeper and unknown layer of his personality is capable of supernormal cognition at least in the field in which his genius lies. All attempts of normal and abnormal psychology to explain genius in terms of 'heredity', 'constructiveness', 'concentration', 'patience', 'common sense', 'anticipation', 'breadth of mind', 'merely hard work', 'high character', 'talents', 'racial memory', 'dissociation' and 'insanity', etc., have proved unsuccessful. Case-study of genius has disclosed that in many cases—e.g. of idiots playing the most difficult musical compositions with ease and grace, of little children extracting cube roots or stating the number of seconds they have lived quite instantaneously, of infants composing divine music without even an elementary knowledge of harmony and composition, and of child prodigies in

other lines—the conscious mind of the genius does not seem to participate in producing the results which rush into his mind with unusual clarity from where he does not know. F. W. H. Myers was, therefore, right in thinking that 'An "inspiration of Genius" will be in truth a *subliminal rush*, an emergence into the current ideas which the man is consciously manipulating of other ideas which he has not consciously originated, but which have shaped themselves beyond his will in profounder regions of his being'.[58]

Materialization and Ectoplasm

One of the most wonderful, baffling and apparently 'absurd' phenomena, the reality of which, however, has been established beyond doubt in the field of psychical research, is what is known as 'Materialization'. It is a name given to real but temporary formation and appearance of complete or partial human forms or parts thereof, in a seance-room, in the presence of a medium who is kept under full watch and control, purporting to be the manifestation of some deceased relation or friend of one or the other of the sitters. 'Materializations' have various degrees of visibility and lengths of duration. They also differ in size. When completely materialized, they appear just like the ordinary human beings.

The first scientific investigation into materialization was made by Sir William Crookes, the well-known physicist of England, who spent three years on a very thorough and critical examination of the phenomenon happening in the presence of Miss Cook. Prof. Richet, Professor of Physiology at Paris, devoted several years to the study of this phenomenon. Dr. Crawford, Professor of Mechanical Engineering at Belfast, spent five years on the study of materializations occurring in the presence of Miss Kathleen Goligher. Prof. Baron von Schrenck-Notzing, who was Professor of Psychology at the University of Munich, spent fifteen years on the study of materializations taking place in the presence of Eva Carrière, Marthe Beraud, Mdlle. Stanislawa P—. Prof. Gustave Géley, of the Institute Psychologique of Paris, very closely studied the materializations occurring in the seances of Eva C. Prof. F. W. Powlowski, Professor of Aeronautical Engineering at the University of Michigan, studied the phenomena taking place in the presence of Franek Kluski, a Polish medium. Hereward Carrington, a psychical researcher of long standing and experience, observed a number of materializations taking place in the seances of the famous Italian medium, Eusapia Palladino. All these and many other investigators, who have made a careful and thorough investigation into the subject, are unanimous in their opinion that, whatever their explanation and significance, the phenomena were real and objective. To quote a few of them: Hereward Carrington

writes, 'In my estimation, there can be no doubt that materialization is a fact in nature, however incredible it may appear'.[59] Hamlin Garland, who investigated these phenomena for no less than forty years before pronouncing any judgment, writes, 'Magical as they seem, incredible as they are, they happened exactly as I have described them'.[60] Dr. Geley writes, 'I have very often seen complete materialization of a face, a hand or a finger. In most perfect instances the materialized organ has all the appearance and biological properties of a living organ'.[61]

The most authentic and famous case of materialization on record is that which was investigated by Sir William Crookes, who, under sufficiently controlled conditions, saw both Miss Cook, the medium and Katie King, the materialized figure at the same time and had sufficient opportunities of examining them both. He could note even the differences in the rate of the pulses and in respiration of the entranced medium and the materialized form. He also noted that while Miss Cook had her ears pierced for putting on ear-rings, Katie King had not. It is stranger still that the same figure of Katie King appeared in materialized form once again, some sixty years later, in 1931 and 1933, an account of which was published by Dr. Glen Hamilton of Winnipeg, Canada, in the *Psychic Science* for January, 1934. To ascertain the objectivity of this materialization, eight cameras were placed at different angles to take photographic records of the various parts of the figure.

With regard to materializations there are at least three great mysteries. First, whence do they draw the matter of which they are formed? Second, how do they take the form of some one's dead relative or friend? And third, how do they acquire the information they disclose? Much research work has been done to solve these mysteries, which it is not possible to state or summarize here. It may, however, be mentioned that there are two main schools of thought: one holding that the materialized figures are the surviving spirits of the dead, which they claim to be, manifesting themselves temporarily on the plane of matter, we do not know how; the other, which holds that they are born of certain unknown power of the organism of the medium and shaped in accordance with his conscious or unconscious thought. According to this view they are nothing more than bio-dynamic in nature, originating in the seance-room and vanishing therein. The information disclosed by them beyond the knowledge of the medium is, on this view, explained as telepathically or clairvoyantly derived by the medium from the proper sources.

This view gets strong support from the discovery of what is known as *Ectoplasm* in psychical research. In recent years it has been observed by some that some of the materializing mediums have a remarkable power of exuding from their bodies a strange sort of substance, which is a kind of living matter, as it were, and of reabsorbing it into their bodies. It is out of

this strange substance that materialized figures are made under the influence, guidance and control of the conscious and subconscious ideas of the medium, whatever the source or origin of those ideas may be. This mysterious living matter which is a part of the organism is now known in scientific language as *ectoplasm*. Much research work has been done on ectoplasm since its discovery by Prof. Baron von Schrenck-Notzing and Mme. Bisson during their observation of the materializations occurring in the presence of the famous French medium, Eva C. 'The reality of ectoplasm,' says Hereward Carrington, 'seems to have been well established.'[62] Shaw Desmond writes, 'I have at a distance of two feet seen it exude steadily from the body of a woman medium until it filled her lap and then watched it build into a face of a child. All this before experts, in a room not the medium's and prepared against fraud, and in a good strong light'.[63] Dr. Gustave Geley could take a number of photographs of the entire process of materialization from the ectoplasm exuding from the body of Eva C., which vanished into the body after the materialized forms were over. These photographs[64] show the entire process of materialization from the beginning to the end. Of course, all this will sound like an absurd fiction from the 'Arabian Nights'. But truth is often stranger than fiction. In this connection, the words of Prof. Richet ring in my ears. He has said, 'To admit the reality of these phenomena was to me an actual pain . . To ask a physiologist, a physicist, or a chemist to admit that a form that has a circulation of blood, warmth and muscles, that exhales carbonic acid, has weight, speaks and thinks, can issue from a human body, is to ask him of an intellectual effort that is really painful. YES, IT IS ABSURD; BUT NO MATTER—IT IS TRUE.'[65]

The nature of ectoplasm is still mysterious, although much work has been done on it in chemical laboratories, to which there is no time to refer here. It may only be pointed out that it is something objectively real, having physical, chemical and biological characteristics. When it exudes from the body of a medium, her weight decreases and it returns to the normal when the ectoplasm is reabsorbed into the body. Modern psychology and biology do not yet know such a substance.

PARAFFINE-MOULDS AND FINGER-PRINTS

To determine whether an apparently materialized form is objectively real and actually different from the body of the medium, various tests have been devised.[66] Two of them, namely, *Paraffine-Moulds* and *Finger-Prints*, may be mentioned here. For taking moulds of the parts or organs of the materialized form, a bucket of hot water with paraffine floating over it and another bucket of cold water are placed in the seance-

room. The materialized figure is requested first to plunge the part of which the mould is desired in the hot water and then in the cold repeatedly until a thick cover of solidified paraffine is formed, and then to leave the cover on the table by withdrawing the part from it. Curiously enough, many of these moulds are certainly of different shapes from what they would have been had they been of those organs and parts of the medium. Moreover, in these experiments the medium is kept under strict control. Finger-prints and thumb-prints of materialized hands have also been taken on warm dental wax and have been examined by experts and found to be quite different from those of the medium. A remarkable series of thumb-prints alleged to be of Walter, a deceased brother of Margery, a famous medium, have been taken in this way, and on examination by experts found to be identical with those of Walter when he was alive, and certainly different from those of the medium.[67]

Independent Voices and Independent Writing

Some kind of materialization seems to underlie the phenomena known as *Independent Voices* and *Independent Writing.* The former consists in intelligent and responsive sounds being heard in the seance-room, which certainly are not produced by the medium or any of the sitters or by any other fraudulent means; and the latter consists in scripts produced on clean slates or pieces of paper, without any known agency. To get the former, sometimes trumpets are placed in the room, and to get the latter, slates, paper and pencil are placed on the table. Those who have investigated these phenomena have become convinced of their supernormality. Some of them have presumed, and have sometimes verified it with observation, that to produce sound a larynx and a mouth should have been materialized; and to produce independent writing a hand. On the basis of his observation, William Crookes has written, 'A luminous hand came down from the upper part of the room, and after hovering near me for a few seconds, took a pencil from my hand, rapidly wrote on a sheet of paper, threw the pencil down, and then rose up to our heads, gradually fading into darkness'.[68] For Independent Voices, Findlay's 'On the Edge of Etheric' may be read.

Trance-mediumship

The phenomenon of mediumistic trance is quite well known and common in India. Its main features are a complete or partial but temporary loss, withdrawal or disappearance of one's personal consciousness and substitution or appearance in its place of a different one, sometimes with greater powers of

knowledge and action than those possessed by the normal consciousness, displayed through the same bodily organism. The new consciousness purports to be of some one else. There are variations in the degrees of withdrawal and possession. Sometimes supernormal information is given by the possessing or controlling consciousness, which is not explicable in terms of the knowledge of the medium; and quite different traits of personality than those of the entranced medium, are displayed by the controlling consciousness.

The credit of initiating a scientific investigation into this type of phenomenon in the West goes to the great psychologist, William James, who in 1885 discovered a very strange woman, Mrs. Leonore E. Piper, who was capable of passing into a trance, when her personal consciousness appeared to have been withdrawn, leaving the physical body under the control of seemingly some other intelligences who professed to be denizens of the other world and to be there to communicate with their earthly relations and friends. Thinking her to be a great find of scientific interest, James introduced her to Dr. Hodgson, the Secretary of the newly started American Society for Psychical Research. From 1886 to 1911, Mrs. Piper was under the full watch, control and observation of a large number of scientific investigators of Europe and America, who made a thorough and critical study of her trances and of the information and messages given by the trance-personalities. Despite other differences, there is a general agreement among the investigators on that in her trances there is much supernormal material which needs new concepts for description and explanation. As Tyrrell puts it, 'All the investigators who made a study of the case agree that the evidence for supernormality is incontestable'.[69] According to William James, 'She knows things in her trance which she cannot possibly have heard in her waking state'.[70] Opinion is sharply divided on the questions: (1) whether the supernormal information disclosed by Mrs. Piper in her trances through the alleged controls coming from the other world was actually due to the real surviving spirits of the dead they claimed to be, or due to some capacity of supernormal cognition possessed and exercised by the subconscious stratum of her own mind; (2) whether the alleged extraneous personalities are actually what they claimed to be or they were her own secondary personalities of the type created in hypnotic trance or hysteric dissociation. Dr. Hodgson, Prof. Hyslop, Sir Oliver Lodge, Sir William Barrett, F. W. H. Myers, and to some extent Prof. William James became convinced that through the entranced mechanism of Mrs. Piper some extraneous personalities communicated with the sitters. According to Dr. Hodgson, for instance, 'The chief communicators . . . . are veritably the personalities that they claim to be, that they have survived the change we have called death, that they have directly communicated with us whom we call living

through Mrs. Piper's entranced organism'.[71] According to Mrs. Henry Sidgwick, on the other hand, the alleged communicators in Mrs. Piper's trance are 'some phase or element of Mrs. Piper's own consciousness' and nothing more than 'hypnotically constructed pseudo-personalities'.[72] The supernormal and veridical knowledge displayed by these pseudo-personalities is explained by Richet, Podmore and others, who did not believe in survival, on the assumption of telepathy and clairvoyance having been exercised by the subconscious mind of Mrs. Piper.[73]

The theory of telepathy as a rival to that of survival, however, fails to explain certain very peculiar and marked features of trance-mediumship, some of which may be pointed out here. Trance-personalities announce themselves to be particular persons and sometimes give convincing proofs of their identity. In case of there being more than one communicator, each of them appears to be a distinct personality with marked differences from others in the power of control and communication; and the change from one to the other communicator is clearly felt by the sitters. Further, the various communicators betray degrees of ignorance and familiarity with the sitters. Some of the trance-personalities do disclose facts which were known only to the deceased persons whose surviving spirits they purport to be.[74] These selective and personificatory features of trance-mediumship cannot be explained without a remainder by the theory of telepathy and clairvoyance.[75]

In recent years other trance-mediums—Mrs. Verall, Mrs. Osborne Leonard, Mrs. Holland, Mrs. Willet, Mrs. Thompson, Mrs. Elliot, Miss Verall and Miss Rosemary—have come into the field, whose trance-phenomena have thrown greater light on the problem 'Telepathy versus Survival'. They have greatly co-operated with the investigators in settling the issue by undergoing several tests—such as the 'Post-mortem Letters Test', 'the Scholarship and Classical Knowledge Test', 'the Book Test', 'the Newspaper Test', 'the Cross-Correspondence or Concordant Automatism Test', 'the Proxy Sittings Test', 'the Reaction Test', 'the Psychoanalytic Test' and 'the Psycho-galvanic Reflex Test' —which cannot be described here in details.[76] The conclusion towards which this recent investigation is heading is that there is something more in the trance-phenomena than can be satisfactorily explained in terms of secondary personality, telepathy and clairvoyance. In the words of Richmond, the evidence 'signifies some influence of their (the dead) personality operating in some way that we do not understand'.[77] Now, as Carrington puts it, 'practically every psychical researcher agrees in thinking that the evidence in favour of the spiritualistic hypothesis is now so strong that it may be justifiably employed as a *working theory*... until further discoveries necessitate some change or changes in the theory adopted'.[78]

Reminiscence of the Past Lives

The survival hypothesis is further strengthened by the cases which now and then occur, in which some child happens to retain a memory of certain events, objects, persons, relations and places, said to have been experienced in some previous life. Such cases have occurred not only in India, but also in other countries, as appears from several books that have recently been published on the subject of *Reincarnation* by scientific writers.

One of the most remarkable cases supporting the theory of rebirth was published in the Italian periodical, *Filosofa della Scienza* of January, 1911, and in the *Quarterly Journal of Psychic Science*, July, 1930. In brief it is this: Alexandrina, a five years old daughter of Dr. Carmelo Samona of Palermo in Sicily, died on March 15, 1910. Three days after, the mother saw her in dream, saying, 'Mother, do not cry any more . . . I shall come back again'. Being curious, the parents attended some seances, in the first of which the spirit of Alexandrina confessed that she had appeared in the dream, and said again, 'Little Mother, do not cry any more. I shall be born once more with you as my mother'. In another, she made a strange and unexpected statement, 'Mother, there is another as well within you' indicating that the mother would give birth to twins, which she had never done before. On November 20, the mother actually gave birth to twin daughters, one of whom, the younger, grew up in very close resemblance with the deceased Alexandrina, even with a tendency to be left-handed. Later, on the occasion of a proposed visit to a town, Monreale, which the twin daughters had never seen before, the younger daughter, who was named Alexandrina, expressed her familiarity with the town, which the parents had visited with the deceased Alexandrina.[79] There are two other very interesting cases which may be referred to here, in both of which memories of a long past are displayed. One of them is described in 'Soul of Nyria' by Mrs. Campbell Praed. In this case a lady remembered very vividly and in minute details her life and times in the ancient Rome. The other case is that of Rosemary, described in 'After Thirty Centuries' of Frederic H. Wood, and in 'ancient Egypt Speaks' of A. J. Howard Hulme and Frederic H. Wood, in which the English girl remembers her past life in Ancient Egypt. The authors of these works say, 'We may place on record that the Rosemary case appears to provide definite evidence for reincarnation'.[80] Coming to India we refer here only to two well-verified cases of rebirth, namely: (1) that of a son of Kekai Nandan Sahai of Bareilly, who at a very tender age remembered details of his previous life at Benares,[81] and (2) that of Miss Shanti Devi of Delhi, who, some years ago, happened to remember many details of her previous life at Muttra, which were remarkably verified by a number of investigators.[82]

THE BEARING OF THE SUPERNORMAL FACTS ON THEORY OF HUMAN PERSONALITY

We have had a bird's-eye view of some of the many supernormal facts and phenomena which have been scientifically investigated in recent times and accepted to have actually taken place by a large number of competent investigators. We may not have come across any one of them in our own lives, and many of them may appear quite absurd and impossible to us, yet we cannot set aside the testimony of the great scientists who have been quoted above. In view of the great testimony we have on them, we cannot deny them *a priori*. We have to accept them as a part of the data for psychology and biology as long as we have not come to a negative conclusion through our own investigation into them. Supernormal data have at least as much right to influence General Psychology as the abnormal and subnormal have, if not more. The psychology of human personality has, therefore, to be rewritten in the light of these data as it has already been written in the light of the abnormal and subnormal ones in the recent past.

Of all the facts of supernormal nature, 'Telepathy'—or 'Extra-sensory perception', as it is now generally called—stands high with regard to both evidence and implication. Its importance cannot be too much exaggerated, and McDougall was right in saying in his Presidential Address to the Society for Psychical Research, 'Its importance for Science and Philosophy will far outweigh the sum of the achievements of all the psychological laboratories of the Universities of the two continents'.[83] So was Warcollier in writing, 'Research in telepathy may revolutionize our concept of mind as much as the discovery of radium revolutionized that of matter'.[84] If nothing else but telepathy, of all the supernormal powers, is accepted as operative in man, we have to considerably change our conception of human personality and that of human relationship. Admission of telepathy necessarily leads to the admission of independence of mental activity of the brain and the nervous system, for all attempts to explain telepathy in terms of physical radiation of brain-waves have proved unsuccessful.[85] 'A physical theory of telepathy,' in the words of Tyrrell, 'is completely untenable.'[86] Rhine's investigation suggests that extra-sensory perception 'is not a sensory phenomenon' and leads him to 'the view that the percipient's mind "goes out" to the object or mental act that is to be perceived, and that this projection of mind is a peculiarly non-mechanical procedure'.[87] This theory of 'going out' gets support from the facts of 'psychic excursion' occurring in dream, sleep, hypnotic trance and 'astral projection'. These all indicate that over and above the physical body, and separable from it at times, there is some superphysical or spiritual principle in man, which is capable of directly knowing objects at distance as well as thoughts

of other individuals. Every human personality must be having behind it such a spiritual principle, for every one, as facts indicate and investigators affirm, can at times acquire supernormal knowledge and can receive and transmit thoughts.

That this paraphysical principle in human personality is not only capable of supernormal *knowledge* but is also capable of supernormal *action*, is clearly borne out by the facts of 'exteriorization of motivity', 'telekinesis', 'levitation of objects', 'raps' and 'poltergeistic phenomena'. It is further capable of controlling, curing, recuperating and building the body and its organs, as it appears from the facts of 'supernormal control' and 'miraculous cures' mentioned above. Its extraordinary creative power is revealed in 'materializations' which take place in a remarkably short time.

From the extraordinary facts we have briefly surveyed, we cannot set any limit to our cognitive, effective, curative and creative powers, as the little we know about them at the present stage of our research is enough to indicate that they are not limited in time and space. Both telepathy and clairvoyance have been found functioning independently of them. Clairvoyance knows no obstruction. In exercising psychometry the medium displays a kind of omniscience, as it were, unlimited by things, time or space. 'Precognition' and 'Retrocognition' further support this contention. Memory has been found extending to thousands of years. Cases of spiritual healing effected at Lourdes are so marvellous that no limit can be put to the healing power inherent in the spiritual principle.

That this principle, which appears to be superphysical, superphysiological, superconscious and even supermental—yet a veritable factor in human personality—may not be subject to death, is evident. Firstly, from the fact that its existence and functions, as revealed in the facts surveyed, do not seem to be dependent upon the physical body. For, what does not depend for its existence and functioning upon anything, can certainly continue to exist and function when that thing is destroyed. Secondly, from the fact that this hypothesis is supported by a good deal of actual evidence in favour of the existence and functioning of the spiritual principle in the 'spiritoid' phenomena, such as veridical 'automatic writing', 'automatic speech', 'independent writing', 'independent speech', 'possession', and 'spirit-communication', etc. Much weight is added to this sort of evidence by the phenomena of the 'visions' of the dying persons and of their attendants, 'apparitions of the dead', 'ghosts' and 'haunted houses'. The facts of 'psychic excursion' in dream, sleep and hypnotic trance, 'apparitions of the living', voluntary 'astral projection' further strengthen the belief, because they all indicate that in addition to the physical body man possesses another body, call it the 'etheric double', the 'subtle body', the 'astral body', or the 'alter ego', which seems

to be a superior kind of duplicate of the physical body,—or, as I should put it, whose inferior duplicate the physical body is. The physical body appears to be merely an external shell of the astral which is separable from it.

In fact, as it has already been pointed out, the evidence for 'survival' of the spiritual principle—the relation of which with the astral body is not yet fully known—and its ability to influence the mind and body of a living person, is now overwhelmingly great and cannot be easily explained away. To escape this hypothesis we have to take the help of such other hypotheses as are equally unpalatable and unacceptable to orthodox psychology, for the only alternative hypothesis to that of survival is unrestricted powers of 'extra-sensory perception' and 'telepathy'. But even these are incapable of explaining the selective personificatory nature of the 'spiritoid phenomena', to explain which the hypothesis of communicatory survival seems to be the most natural, simple and direct one. There is, of course, no doubt that the subconscious and unconscious strata of our mind sometimes indulge in false personification, as it appears in hysteric and hypnotic secondary personalities. But what is true of the lower strata of the mind may not be true of that stratum of personality which is possessed of higher supernormal powers we have described. Therefore, until more light is received on the working of the supernormal factors in our personality, we have to accept the theory of 'survival' as the only satisfactory explanation of those cases of 'spirit-communication' and 'possession', (i) in which the information conveyed is such as was unknown to any living person, but was definitely known to the deceased, and proves veridical later on; (ii) in which the communicator reveals his identity by means of his peculiar mannerism, characteristic attitude and reactions, and memory of significant and verifiable events, unknown to the medium and the sitters; (iii) in which some such deceased personality is alleged to communicate as is quite unknown to the sitters, but on subsequent enquiry is found to have been already dead, and the information given by it to be significant and veridical; (iv) in which the communicator writes in a hand and script closely similar to those of the deceased and markedly different from those of the medium; (v) in which the knowledge and culture of the communicator are decidedly superior to those of the medium; (vi) in which the messages are received through cross-correspondence; (vi) which are supplemented by supernormal dreams, apparitions and hauntings, etc., connected with the deceased; and (vii) in which psychoanalytic, reaction- and galvanic tests have established differences between the personalities of the medium and the communicator. Telepathy and survival are not really incompatible with each other. Both may hold good. The first in fact implies the other; and what it tries to ward off by the front-door is allowed to enter by the back-door; for once the materialistic and mechanistic

bias is cast away by admission of telepathy, there hardly remains any difficulty in accepting independence of spirit from bodily states. And what can function independently of the body may very well survive its destruction.

Once survival is accepted as highly probable, as it now seems to be, and also a will on the part of the surviving spirit to communicate with the living and to materialize—which is a sure indication of the interest of the deceased in this world—, it is not difficult to understand that the surviving spirit may reincarnate on the earth, and may also occasionally remember some events and episodes of some of the past lives.

These are the simplest conclusions we can draw from the facts discovered and investigated by the new science, the 'Psychical Research', with which scientific psychology should now establish a contact. In fact, Psychical Research, which is but another name of the investigation into supernormal facts and phenomena connected with human personality, should now be conducted by trained psychologists and should be regarded as a branch of Psychology just as Psychoanalysis and Abnormal Psychology already are. Supernormal psychology deserves as much attention of humanity, if not more, as the normal, abnormal and subnormal ones do. And it is this science alone, among all the sciences, that promises to bridge the wide gulf existing today between the outlooks of the modern West and the ancient East—the land of Yoga or realization of the potentialities of the Psyche.

Concluding Remarks

In the short time at my disposal I have tried to place before you without much expression of opinion on my part, mostly the observations and conclusions of eminent workers in the field of psychical research. You may refuse to accept these statements at their face value but you have no right either to reject them. It is only after impartial scrutiny of evidence and careful scientific and if possible laboratory studies carried out by competent psychologists that the value of the evidence in favour of psychic phenomena may be appraised. It had been the main object of my address to invite you to undertake these tasks of observation and scrutiny.

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SECTION OF ENGINEERING AND METALLURGY

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Presidential Address

(*Delivered on Jan. 3, 1943*)

THE THEORY AND PRACTICE OF SEWAGE PURIFICATION, WITH PARTICULAR REFERENCE TO WORKS AT DADAR, BOMBAY

My first duty is to thank the Executive Committee of the Indian Science Congress Association for the signal honour that they have done me in nominating me to this Chair. I find that a convention has been established in this Association regarding the selection of the subject of the Presidential Address. A President is expected to speak on a subject with which his life-work has been identified in which he has done original work. The Engineer, unlike the Scientist, does not often get opportunities of doing original work in his professional career, as much depends on what comes in the way of his practice and the position he holds. I do not profess to have done much original work in the field of Public Health Engineering with which I have been associated for the past three decades, beyond collecting useful data and statistics extending over a period of eight years in connection with the sewage purification works at Dadar (Bombay) belonging to the Bombay Municipal Corporation. These works serve the recently developed northern parts of Bombay City which were not provided with sewerage facilities up to the year 1934. Bombay is the first city in India to operate such works under skilled technical and scientific supervision with requisite laboratory control. I, therefore, propose to confine my attention today to the presentation of the data in the belief that they may prove useful to engineers and chemists engaged on similar works in India. Before doing so, I shall briefly review the modern trends in sewage disposal practice.

MECHANIZATION

One most marked trend is the mechanization of the treatment plants. Even the old sewage works, which formerly depended for the removal of sludge lying at the bottom of the

sedimentation tanks by squeeges worked with manual labour, are being remodelled and fitted with mechanical appliances to facilitate the cleaning of the tanks while in operation at very frequent intervals. New works especially of the larger type are invariably being provided with mechanical apparatus to minimize the manual control as far as possible. Such was not the case 30 years ago when the designer tried to avoid mechanization except perhaps for screening, cleaning of detritus tank, and for distributing sewage liquor on a trickling or percolating filter. In American cities mechanization is made use of in smaller plants even for screen raking. This has affected considerably the problem of removal of screenings and grit, sedimentation of sewage and final settlement of the purified effluent, and it has been reflected in the change-over from rectangular to circular types of tanks used for preliminary and final settlement. In the former days, rectangular tanks were in use as they were best suited for hand cleaning, but today circular tanks are gaining favour because they can be easily adapted to work in conjunction with mechanical scrapers. Appliances to suit rectangular tanks have also been developed and are in operation at a few plants. At Dadar six rectangular tanks without scrapers and one circular tank with a scraper are working side by side as preliminary sedimentation tanks. Though economic considerations play an important part in the selection of mechanical apparatus or otherwise, plants installed in the midst of residential areas should be provided with mechanical appliances as they are helpful in minimizing nuisance from smell when the various daily operations required for the efficient performance of the plant as a whole are carried out.

Pre-treatment of Sewage

The next trend is in regard to pre-treatment of sewage prior to its entry into the preliminary sedimentation tanks. Pre-treatment was unknown a few years ago, but it has recently become a routine adjunct of sewage disposal plants in America. The necessity of introducing pre-treatment was felt first in the case of plants worked by the activated sludge process in order to keep sewage fresh and to increase the percentage removal of suspended solids by the preliminary sedimentation tanks before admission into the aeration tanks. Pre-treatment has been developed on two lines—pre-aeration and flocculation.

Pre-aeration.—Pre-aeration is helpful in keeping sewage fresh and in the separation of grease. The contact period may vary from 10 to 15 minutes and the amount of air blown varies from 0·25 to 0·5 c.ft. per gallon of sewage treated. At Coleshill Works, Birmingham, constructed in the year 1934, a pre-aeration tank of 30 minutes is in use and is giving satisfactory results, while the one constructed at Berlin for a similar

purpose has been abandoned as it was found that the money spent on aeration did not bring an adequate return. It is still to be proved that pre-aeration has distinct advantages, but it is desirable that in preparing designs for new works where sewage is apt to get septic on account of its long travel through sewers to the treatment works, sufficient space should be left for the installation of pre-aeration tanks in the future and levels of the various units of the plant should be accordingly adjusted.

Flocculation.—Flocculation is practised either with submerged paddles having a peripheral speed of 1·5 to 1·7 feet per second or by blowing 0·05 to 0·2 c.ft. of air per gallon of sewage treated. Paddles give better results than compressed air because the optimum air required to be blown to maintain the solids in suspension disintegrates the floc. Flocculation with paddles is also adopted in the case of chemical precipitation tanks to secure thorough mixing of chemicals and thus to help in reducing the dose. A few laboratory experiments were conducted at Dadar in a small flocculator to investigate the following points in respect of mechanical flocculation: (1) whether flocculation prior to preliminary sedimentation has any beneficial effect on local sewage, (2) whether the sedimentation period in the preliminary settling tanks could be reduced, (3) time of flocculation required, and (4) whether any modification in the operation of the flocculator was necessary. The following conclusions were arrived at: (1) Flocculation of sewage prior to primary sedimentation definitely removes 15 to 30% more suspended solids and brings about substantial reduction in 4 hours oxygen absorption, and B.O.D. depending upon strength of sewage and gives a quicker settlement in subsequent clarifier. (2) Increase in time of flocculation up to 30 minutes gives better results but beyond 30 minutes the improvement is not appreciable. (3) Rate of settlement after flocculation is higher and in case of quiescent settlement not more than 30 minutes sedimentation is required. (4) Sedimentation prior to flocculation is not necessary; on the contrary, flocculation without previous sedimentation gives better results. (5) Addition of 10% activated sludge to sewage prior to its flocculation gives better results. In this case also increase of flocculation period up to 30 minutes improves the quality of the effluent. These results indicate that where activated sludge plants are already in operation, flocculation of raw sewage with 10% of activated sludge will enable the primary sedimentation tanks to take greater load or to produce better effluent.

Chemical Precipitation.—Chemical precipitation is being revived. In the early days of sewage purification it was in the forefront but it fell into disfavour for two reasons, viz. the difficulty of disposing large volumes of sludge produced and high cost of chemicals. Its revival is to be found in the plants of certain American cities where special attempts are being

made to keep down the cost of chemicals. Special appliances have also been developed to secure thorough mixing of chemicals and sewage without causing any waste. This treatment provides a degree of purification intermediate between plain sedimentation and oxidation. It removes about 80% of suspended solids. The reduction in B.O.D. of sewage varies from 60 to 65% as chemicals are not helpful in the appreciable removal of dissolved organic matter. Tanks used for chemical precipitation are not different from the ordinary settling tanks provided with mechanical devices for the removal of sludge and consequently any plant provided with these tanks can be used either for plain sedimentation or chemical precipitation. This flexibility in operation has encouraged some cities in America to use the tanks as plain sedimentation tanks in certain months of the year, and as chemical precipitation tanks during such months of the year when either the sewage is stronger or the volume of diluting water is insufficient for self-purification. In some American cities a magnetite filter is provided at the periphery of the chemical precipitation tank to improve the quality of the effluent before discharge into diluting waters. This innovation seems to influence the design of sedimentation tanks in regard to structural details. In the design of the purification works for the central and southern areas of the city of Bombay the sedimentation tanks are proposed to be worked as chemical precipitation tanks during the four hot months of the year when the sewage is very strong. The proposed design allows for the addition of a sand filter in the future. It is also suggested that activated sludge with flocculators should be used and to increase the efficiency of plain preliminary sedimentation to keep down the recurring expenditure on chemicals.

Activated Sludge Process

The Activated Sludge Process has now passed the experimental stage and has become the most prominent mode of treatment. It can be safely relied upon to produce stable and sparkling effluents both for large and small installations, provided skilled and scientific supervision can be afforded for its operation. It has been proved to be suitable for treating sewages containing appreciable quantities of waste from packing-house, vegetable-canneries, rayon mills and many other trade wastes. It, however, cannot treat satisfactorily sewages containing waste from metal works, dairies and textile mills. The process is 'very sensitive' and gets easily upset by factors like septicity of raw sewage, variations in the quantity and strength of incoming sewage, return of strong supernatant liquid from the digestion tanks to the sewage ahead of preliminary sedimentation tanks and relatively large proportions of industrial wastes.

Diffused Air and Surface Aeration.—It is practised under two main categories—air blowing or diffused air and surface aeration or mechanical agitation. In the case of the former, compressed air is used while aeration in the latter is provided by the absorption of the atmospheric oxygen by mechanical means. Out of the numerous methods developed in Great Britain for surface aeration, only two methods, the Simplex and the Hartley, appear to have stood the test of time. The most debatable point on which a consensus of opinion has not yet been reached among engineers is the relative economic superiority of the two categories. The opinion formed in America as a result of the working of about 100 mechanical plants, 200 diffused air plants and about 20 combined mechanical and diffused air plants, is in favour of the diffused air method in the case of large plants treating 4 m.g.d. and larger volumes of sewage. In regard to plants of less than 4 m.g.d. capacity, the American view appears to be that each case should be considered on its own merits after taking into consideration the local conditions and the variations in the flow and characteristics of sewage. This view, however, has not yet been accepted in English practice where majority of the plants are of less than 4 m.g.d. capacity. The opinion in that country in this respect is still wavering. The working of the Simplex plant at Dadar has created an impression that it would be safer to follow the American practice as it appears to be suited to Indian conditions.

In the new installations worked on this process, every attempt is being made to lighten the load on the plant by efficient preliminary treatment and dilution. Interest has therefore been awakened as to how the preliminary treatment can be improved to produce settled liquor of uniform quality for feeding the aeration tanks. Dilution is arranged for by returning as much surplus sludge as possible, in some plants even up to 100%. In the designs of new plants sufficient room is being provided in the aeration units to cope with the increased volumes of return sludge.

A great diversity prevails in regard to the detention period in the aeration tanks and the use of air. Aeration period depends primarily upon the devices used for aeration, strength of sewage to be treated and the degree of purification desired. Plants working on surface aeration require larger detention periods, nearly three times of those working on diffused air system. At some large recently constructed American plants where diffused air system is in vogue, aeration periods of 3 to 3½ hours have been employed. At Milwaukee, Wards Island Plant, New York, Cleveland (Easterly), this period has been 6, 5½ and 4½ hours, respectively. Experimental work is in progress to find whether the detention period can be reduced still further. At the West Side Works, Chicago, an experimental activated sludge

plant treating an Imhoff tank effluent is found to work satisfactorily with aeration periods varying from 1·25 to 2·1 hours. The supply of air in American practice varies from 0·42 to 1·85 c.ft. per gallon of sewage treated. At Calumet plant, Chicago, it is about 0·42 c.ft. per gallon, at Milwaukee between 1·17 to 1·85, at Wards Island plant between 0·65 and 0·91 and at Cleveland between 0·92 to 1·12. Examples in English practice indicate that a longer detention period with a small supply of air is preferred. At Mogden plant near London, a normal detention period of about 8 hours has been provided with an air supply of 1½ c.ft. per gallon of sewage treated. Manchester uses a detention period of 17 to 18 hours with a smaller air supply of 0·75 c.ft. per gallon of sewage treated while Coleshill (Birmingham) plant works with a detention period of 14 hours and an air consumption of 0·75 c.ft. per gallon of sewage treated.

This process is also used in the existing purification plants to reduce the load on the secondary treatment. In Great Britain, a number of activated sludge plants have been interposed between the existing sedimentation tanks and the biological filters, when the latter were overloaded and additional filters had to be constructed. The activated sludge process in this case is employed to remove only the colloidal matter from sewage, i.e. it is worked up to the clarification stage, and the filters, being more suited for the nutrification of dissolved organic matter, complete the nutrification stage. The clarification stage, however, produces a type of activated sludge which is not sufficiently active, and hence cannot be used for injection of incoming sewage unless it is reactivated or regenerated. This led to the adoption of separate units in addition to the normal aeration units for the reactivation or reaeration of the return sludge. It is now usual to provide one extra unit for 5 units where sewage is of ordinary composition and one in 3 to 4 units for stronger sewage or for sewage containing trade wastes. Manchester, where strong sewage is treated, is working activated sludge plants both with and without reaeration units and the experience thereat has shown that at the time of peak loads when there is a sudden change in the composition of sewage due to the discharge of trade wastes, the one provided with reaeration units recovers earlier than that without reaeration units. In Mogden plant, England, where activated sludge process is used, provision has been made for reaeration of return sludge. Experience has conclusively proved that if at all reaeration is to be adopted, it must be complete and not insufficient, otherwise no useful purpose is served and the money spent on reaeration is wasted. No definite standards have yet been laid down regarding the reaeration units. A good deal of investigation is still going on to find the suitability or otherwise of these units. The main criterion for the successful working,

according to some workers, is that solids in the reactivation tank should be 30 to 50% on one hour's settlement and the moisture content of the activated sludge should be about 99·5%.

Reaeration of return sludge.—Reactivation of return sludge in surface aeration plants can only be successfully achieved by working them with compressed air, as at Dagenham, England. Experiments were tried at Dadar for three months by isolating one row of aeration cones for the reactivation of the return sludge and even though the solid contents of the sludge were between 20 to 40% on one hour's settlement, the sludge did not seem to have benefited appreciably. Experiments were also tried at Dadar to work the plant up to the clarification stage only but they did not succeed as the sludge produced in this stage was unsuitable for injection of raw sewage. The sludge was also offensive in character.

It has yet to be proved on a plant scale that the capacity of a surface-aeration activated sludge plant working beyond clarification stage can also be increased by reaeration of return sludge in separate aeration units worked with compressed air.

Tapered aeration.—An hypothesis has been lately advanced that incremental addition of sewage to returned activated sludge along the line of flow would help to equalize the physical and biological phases of the activated sludge process and thereby increase its efficiency or economy. As a result thereof in the design of the Tallsman Island Activated Sludge Plant of New York City the introduction of sewage at three points along the aeration units has been provided. The results of this innovation will be awaited with interest.

Biological Filters

It was thought that with the advent of the activated sludge process the biological filters would not be considered for new installations. As more experience was gained of the working of the activated sludge process, its main drawback, viz. sensitiveness, was prominently noticed. It was also realized that for efficient working of the plant very strict scientific supervision with laboratory control was necessary. This focussed the attention of the engineer on the old filter as it had proved its value as a more robust plant to withstand sudden variations in the strength and volume of sewage without impairing the quality of the effluent. Investigations were therefore undertaken to understand thoroughly the fundamental principles under which the filter worked. Simultaneously experimental work was also done to get over the three drawbacks of the filter by suitably modifying its design. The main drawbacks of the filter are: (1) large space requirement, (2) aerial nuisance from smell, and (3) fly nuisance. In experimental installations the first drawback

was got over by increasing the load ratio, the depth of the filter, and by the provision of forced draft aeration. The second and the third were got over by enclosing the filters. The pilot installations have given satisfactory results at some plants and it appears that an enclosed filter with forced draft aeration will have a bright future as it is cheaper both in initial cost and maintenance and does not require so much skilled supervision for its operation as an activated sludge plant. Experimental work is also in progress to achieve this object by introducing other modifications in the filter, such as, stage filtration. Experience of the various workers on two stage and multiple stage filtration has yet to be co-ordinated and correlated. There is, however, no doubt that the old biological filter with suitable modifications will considerably influence the technique of sewage purification in the near future.

At Dadar, an enclosed filter using forced draft aeration is in operation from April, 1941. This is the first installation of its kind in India.

Sludge Disposal

Land treatment of sludge, though once highly popular, has fallen into background due to the large areas of land required and smell nuisance created. Coastal towns like London, Manchester, Glasgow, New York, Southampton, barge the sludge to the sea. Inland towns dispose of the sludge either by burying, lagooning or drying in the open on beds. The last two methods create nuisance and get dislocated by weather conditions. In order to avoid the nuisance and dislocation by weather, some American cities use glass-covered beds. Pressing is practised at some places. The use of vacuum filters was not common a few years ago due to the high cost of the 'conditioner' but of late it has made a good progress in U.S.A. where to keep down the dose of the 'conditioner' the sludge is first elutriated. The dried sludge is sold as a fertilizer at many plants. Rotary driers are used in the old installations while flash drying has been adopted in some new plants.

'Digestion' in separate tanks, called 'digesters', is growing in practice superseding the old method of digesting sludge in Imhoff tanks. Digestion may be single or multi-stage and is usually mesophilic. The gas obtained from digestion tanks is used for power and fuel purposes. The digested sludge can more easily be dried on drying beds in the open without creating nuisance. The most modern trend in sludge disposal practice is that of incineration. A few plants in American cities are incinerating the sludge. Vacuum filtration, flash drying and incineration have not been adopted in Great Britain. Digestion in separate tanks is getting more and more popular in that country. A single stage digestion tank is in operation at Dadar

plant for five years. This is also the first plant of its kind in India.

These are some of the most modern trends in sewage works practice. I now turn to the details of the Dadar purification works.

Dadar Purification Works

The sewage purification plant at Dadar is designed and operated for producing an effluent conforming to the standards laid down by the Rivers Pollution Board, England, for 'combined' sewage. The treatment embodies the following features:—(1) grit or detritus chamber, (2) a screen, (3) six plain rectangular sedimentation tanks and one circular tank, (4) thirty-six aeration units of the Simplex type arranged in six rows containing six aeration cones in each, (5) eighteen final settling tanks, (6) one separate sludge digestion tank followed by ten drying beds, and (7) an enclosed type forced draft filter.

It was intended to extend this plant from 4 to 8 m.g.d. but due to the conditions created by the war, the work on the extension had to be deferred and the plant has therefore been overloaded. The total flow reaching the plant is about 10 m.g.d., out of which about 5 m.g.d. are treated in the activated sludge plant, about 0·75 m.g.d. in the enclosed filter and the remainder is by-passed after preliminary settlement into the open storm water drain close by.

Grit or Detritus Chamber.—The function of a grit or detritus chamber is to remove as much mineral matter as possible from sewage before its entry into the preliminary sedimentation tanks. In English practice, where a majority of the sewage systems are on the combined system, the Royal Commission recommended that there should be at every plant two detritus tanks, each of a capacity of one-hundredth of the dry weather flow. This rule, however, is not being adhered to in English practice. In India, where partially separate system is usually adopted, there might be some road detritus admitted into the system during monsoon period, but generally mineral matter in the form of ashes, coal dust, earth, sand, etc., is introduced all the year round through house connections due to the use of these materials in every household for cleansing utensils. These materials being finer than road detritus, the organic matter contained in the sewage gets mixed with it, and this complicates its removal as well as disposal. If the velocity of sewage in the grit chamber is limited to 0·8 to 1 c.ft. per second, material of 0·2 mm. size and larger is removed. This velocity must be constantly maintained under all the conditions of flow and for this purpose a flexible breadth control arrangement preferably at the entrance throat is desirable. As sufficient data were not available regarding the size of grit entering the sewers in Bombay, the grit chamber at Dadar was based on English practice. The

channel was made parabolic in form to maintain a constant velocity under all conditions of flow but this object has not been fulfilled in actual working. The screen follows the grit chamber at Dadar plant. It should have been on the upstream side of the grit chamber to arrest the floating material, such as rags, cellulose matter, etc., but due to its position on the downstream the floating material enters the grit chamber and gets entrapped with grit and lighter putrescible organic matter and settles at the bottom. This makes grit more foul and difficult of segregation from organic matter When removed from the chamber, it causes nuisance. The velocity of sewage approaching the screen should not fall below 1·25 feet per second at the time of minimum flows and should not exceed 3 feet per second at the time of peak flows; otherwise, when velocity is low the screen gets choked more frequently and with a high velocity the floating and other matter intended to be arrested before entry into the chamber pass through.

It is found that under tropical conditions grit has to be removed 4 to 6 times a day, otherwise grit deposits get septic and rise to the surface, considerable gasing takes place and the whole tank gets foul and presents a very ugly appearance. Grit removed from the grit chamber at Dadar consists of 60% inorganic and 40% organic matter. The latter putrefies and creates trouble. This susceptibility to septic action has been noted practically at every stage of the plant. Everything connected with the plant has therefore to be kept moving and clean, otherwise any slackness of this idea either in the design or working will make itself felt by presenting ugly patches of sludge rising to the surface within a few hours, which has an adverse effect on the effluent produced by the plant.

No phase of sewage treatment is more unsightly and more conducive to foul odours than that of screening and grit removal. During the grit removal operation, the atmosphere in the vicinity becomes extremely foul. The nuisance from smell can be completely eliminated by enclosing the grit and screening chamber with suitable provision for ventilation, but where cost is a consideration this object can be partially achieved by arranging for the frequent removal of the grit deposited at the bottom of the chamber with suitable mechanical appliances.

The foul nature of the screenings and the grit complicates the problem of its disposal. If they are exposed to the atmosphere without washing, they create smell and fly nuisance. Arrangements for their incineration or burying are essential in the design of new plants, especially if they are located in the midst of residential areas. At Dadar, burying was not feasible owing to paucity of sufficient land and incineration was not provided for. The screenings and the deposited grit after removal had therefore to be disposed of away from the plant. It is proposed to install a washing plant to wash out the putrescible matter

contained in the silt and screenings so that the washed silt and screenings may be used for filling low-lying lands in the vicinity of the plant. This will help to reduce the cost of transport at present incurred in sending these materials away from the plant for disposal.

In American practice, comminutors have been recently introduced which grind the screenings under sewage flow without creating any nuisance and the ground screenings are then passed on with the sewage flow, for being settled out, in the preliminary sedimentation tanks. So far the only advantage claimed for this system is the reduction in nuisance from smell. It has not found much favour in English practice and it is also doubtful whether it would be popular in India as some engineers hold that once the screenings are arrested, there seems no point in adding them back to the sewage since the main objective of sewage disposal is the removal of solid matter of which sewage is composed.

Preliminary Settling Tanks.—A proper design of sedimentation tanks to suit Indian conditions both as regards character of sewage and climate has yet to be evolved. At Dadar, a 'compromise' design had therefore to be adopted. Its shape, viz. hopper-bottom Dortmund type, was based on English practice, while detention period was arrived at after taking into consideration the experience of other plants situated in similar situations especially in the southern parts of U.S.A. The detention period of 1½ hours was chosen against the accepted English and American practices of 24 hours to a week and 3 to 4 hours respectively. Large detention periods are adopted in English practice for equalization of flow and strength of sewage. They are not, however, suited to Indian conditions owing to the susceptibility of sewage towards septicity. At Mogden, near London, two-stage sedimentation has been introduced. There is a likelihood of this innovation being adopted in plants where conditions are similar to those obtained at Mogden. The other basic principles, such as the velocity of sewage passing through the tanks, etc., were adopted from the English practice.

When the preliminary sedimentation tanks at Dadar started working, it was found that desludging had to be done every two hours in cold and hot weathers and every four hours during the rainy season. In the absence of any mechanical devices, greatest difficulty was experienced in the periodical removal of sludge to prevent its getting septic and showing itself in black patches at the surface. It was also found that the sludge sticking to the sides was also getting septic and having a detrimental effect on the settled effluent. Frequent brushing of the sides had therefore to be resorted to. A circular tank of the radial flow type provided with a scraper for the removal of sludge was subsequently added. This tank was designed for a detention period of 3 hours against 1½ hours of the rectangular

tank. A comparative statement showing the performance of the two tanks as regards the percentage removal of settleable solids is given in Table I. It will be seen from the same that the circular tank of the radial flow type is more efficient than an ordinary Dortmund type rectangular tank. In future extension of the plant, provision for radial flow circular tanks has been made. Flocculation of sewage without any chemicals or with the addition of activated sludge prior to its entry into the settling tanks is also contemplated.

Experiments were carried out on the circular tank to ascertain whether the detention period of 3 hours could be reduced to about 1½ to 2 hours without impairing efficiency. Some difficulty was experienced in carrying out the experiments. Owing to the restricted area of the tank, the admission of large quantities of sewage increased the velocity of flow through the tank and more settleable solids passed out of the tank along with sewage instead of being settled inside the tank. The experiments cannot therefore be said to be conclusive, but careful observations taken at the time of the experimental work have given an impression that a detention period of 1½ to 2 hours may be sufficient, provided suitable modifications are made in the design of the tank. This point has been borne in mind in the design of the extension tanks and it is proposed to test them for reduced detention periods after they are constructed.

In the original design, the scraper on the tank (80 to 85 feet in diameter) was adjusted for a speed of 30 and 60 minutes per revolution, but it was found necessary to increase this speed to 15 and 30 minutes per revolution to minimize septic action. It was also found necessary to work the scraper continuously and not intermittently as done in cold countries.

The following improvements are considered necessary in the design of the circular tank: (1) Desludging chamber should be hermitically sealed to prevent the spread of foul odour. If this were done, some arrangement to make the flow of sludge visible will be necessary to avoid thin sludge being desludged, and this will also serve as a check on occasional chokes. (2) The present spacing within the wooden grills is less than ¼″. This should be increased at least ½″ or probably more to prevent constant choking. (3) It is also felt that if air lifts are substituted for scraping machinery, for the removal of the accumulated sludge at the bottom of the tank as is done in the case of circular tank at Emscher (Germany), the tendency towards septicity will still further be reduced.

Aeration Cones.—The aeration period in the original design was restricted to 10½ hours as purely domestic sewage was expected to reach the works in the beginning. This expectation was, however, not realized in practice and the plant had to treat a mixture of trade wastes and domestic sewage from the very

SEWAGE PURIFICATION WORKS, DADAR 1939-40

Working of P.S. and C.F.S. Tanks

All results except B.O.D. expressed in parts per 100,000 p.p.m. (parts per million)

Serial No.	Particulars.	April, 1939.	May, 1939.	June, 1939.	July, 1939.	August, 1939.	September, 1939.	October, 1939.	November, 1939.	December, 1939.	January, 1940.	February, 1940.	March, 1940.	Average of the year.
1	Suspended solids (in sewage) ..	32·7	36·8	37·5	25·6	26·3	26·0	26·8	30·1	29·5	31·4	36·7	34·0	31·1
2	Suspended solids in preliminary settling tank (effluent) ..	10·7	11·8	10·9	9·02	10·4	9·0	9·6	9·5	9·3	11·0	11·2	11·7	10·33
3	Suspended solids in continuous flow settling tank (effluent)	10·6	10·7	10·1	7·6	8·3	7·8	8·2	8·0	9·3	10·2	11·7	10·7	9·4
4	Percentage reduction in suspended solids (from sewage to preliminary settling tank) ..	67·3	67·9	70·9	64·8	60·5	65·6	64·2	68·4	68·5	65·0	69·5	65·6	66·8
5	Percentage reduction in suspended solids (from sewage to continuous flow settling tank)	67·6	70·9	73·1	70·3	68·4	70·0	69·4	70·4	68·5	67·5	68·1	68·5	69·8
6	Four hours' oxygen absorption in sewage	4·85	5·07	5·62	3·21	3·80	4·1	4·64	4·91	4·81	5·01	5·71	4·76	4·71
7	Four hours' oxygen absorption in preliminary settling tank effluent	2·5	2·28	2·80	1·92	2·34	2·17	2·39	2·47	2·72	2·70	2·99	2·30	2·41
8	Four hours' oxygen absorption in continuous flow settling tank effluent	2·32	2·29	2·85	1·76	2·17	2·0	2·20	2·31	2·53	2·62	2·82	2·45	2·36
9	Percentage purification on four hours' oxygen absorption from sewage to preliminary settling tank	48·5	55·0	51·2	40·2	38·4	47·1	48·5	49·7	43·5	46·11	47·6	45·4	48·8
10	Percentage purification on four hours' oxygen absorption (from sewage to continuous flow settling tank) ..	52·1	54·8	49·3	45·2	42·9	51·2	52·6	53·0	47·4	47·7	50·6	48·5	50·1
11	Bio-chemical oxygen demand of sewage parts per million ..	83·3	103·3	128·5	95·3	168·5	191·6	227·8	238·0	207·0	221·3	266·3	209·7	178·4
12	Bio-chemical oxygen demand of continuous flow settling parts per million	40·5	38·51	43·9	40·37	54·64	97·99	107·08	104·9	104·56	110·61	137·4	116·94	83·12
13	Bio-chemical oxygen demand of continuous flow settling parts per million	45·5	39·48	44·01	38·44	80·0	91·35	107·71	104·94	110·70	116·4	146·06	126·15	87·56
14	Percentage reduction from sewage to preliminary settling in bio-chemical oxygen demand	51·4	62·7	65·8	57·6	67·6	48·9	53·0	55·9	49·5	50·0	48·4	44·2	53·4

commencement (*vide* Table II). Experience gained has shown that for combined sewage about 16 hours aeration period is necessary and this has been incorporated in the design of the extension units. The plant was started in the month of October 1935 as per standard working. It took about three months before the right type of activated sludge was produced. During this period various troubles, such as bulking, over-aeration and under-aeration, were experienced and got over. The plant was, from the very commencement, kept under laboratory control where chemical examination and microscopic observations were made from day to day. The textbook characteristics of activated sludge are that it should be golden brown in colour, granular, heavy and crisp in settlement and thriving with a particular kind of biological life. The sludge obtained at Dadar complies with these characteristics only in the rainy season when the sewage is considerably diluted by the entry of rain and subsoil water into the sewers, while in cold and hot weathers the sludge is fluffy, light and faintly brownish in colour. It was soon noticed that the colour of the sludge was more or less influenced by the colour of the trade wastes discharged into the sewers and that there was no point in attaching too much importance to the colour characteristic so long it was not definitely black, for black colour is an indication of septicity. As regards biological life, the sludge on some days in the hot weather is found to be very poor in biological activity and on those days it becomes necessary to reduce the flow in the aeration cones to enable the sludge to regenerate itself. It is only during the monsoon period that a really biologically active sludge is obtained. In spite of the poor quality of sludge in the hot weather in respect of biological activity, the overall performance of the plant is maintained and the final effluent does not deteriorate in quality.

Percentage of activated sludge in aeration cones and dilution.— A great diversion had to be made from the English practice as regards the percentage maintenance of activated sludge in aeration cones. Messrs. Ames Crosta Mills, the promoters of Simplex Surface Aeration method, had recommended that 10 to 12% of activated sludge should be maintained in the aeration cones, but the experience at Dadar has shown that not more than 5% of the sludge can be maintained in the aeration cones during non-rainy season and about 8 to 10% in the rainy season. Whenever these limits were exceeded, the plant got upset. The idea of returning more sludge, gaining ground in English and American practice, was given a trial but it did not improve matters and the only satisfactory way to secure dilution was found in the pumping of a certain percentage of the purified effluent into the plant just before sewage entered the preliminary sedimentation tanks. Had the English or American practice been adhered to, the increase in the volume of the return sludge would have resulted in increasing the suspended solids and in

order to satisfy the B.O.D. demand of the sludge, additional aeration would have been necessary to which the surface aeration plant cannot be adapted. The effluent pumped amounts in volume to 25 to 30% of the total capacity of the plant and it is not only helpful in improving the working of the preliminary settling tanks but is also helpful in reducing foul smell. Dilution can also be supplemented by pumping fresh water from wells or other suitable sources of supply in the various portions of the sewerage system, especially in the hot weather, and this important point of giving dilution both by return of purified effluent and by the admission of fresh water into the sewerage system itself deserves careful consideration by those entrusted with the design of such plants.

The maintenance of a certain percentage of activated sludge in aeration tanks is also measured in terms of the actual suspended solids present in the aeration tanks expressed in parts per million. Here again the standards followed in English and American practice had to be departed from for successful operation. In surface aeration plants, the suspended solids maintained in the aeration cones are much less than those worked with compressed air. In compressed air system maintenance of 1,500 to 2,500 p.p.m. suspended solids in aeration tanks has been possible but experience at Dadar with surface aerators has shown the impossibility of maintaining more than 400 p.p.m. suspended solids. Due to this, the adaptability of the plant to deal with increased strength or quantity of sewage is lessened.

Desludging.—The English practice of periodical consolidation and withdrawal of activated sludge from final settlement tanks prior to pumping it back for injection in the first aeration cone was found to be most unsuited for Dadar plant. In the tropics, the activated sludge is susceptible to septicity, and any attempt at consolidation results in the deterioration of the sludge, which thus becomes unsuitable for injection. Attempts to follow English practice resulted in upsetting the working of the whole plant and making the activated sludge flow out with the effluent and creating nuisance from foul smell. After trying experiments in various ways for about a year, it was conclusively proved that consolidation of the activated sludge in the final settling tanks was detrimental to the satisfactory working of the plant as a whole and that the only method to secure satisfactory performance was to desludge the final settling tanks continuously for 24 hours and that too with the valves on the desludging pipes fully open. This practice, however, has resulted in increasing the moisture content and volume of the sludge. The moisture content of sludge at Dadar has never been below 99·5% as against the sludges of English and American plants which have a moisture content of 98·5%. If the plant had worked on the English or American system, the volume of activated sludge produced for a 4 m.g.d. plant would have been about ¾ m.g.d.,

while at Dadar this volume is as much as 2 m.g.d. This aggravated the problem of the disposal of surplus activated sludge, which was in course of time got over. In the early stages the excess activated sludge was mixed with incoming sewage by discharging it into the sump of the nearest pumping station. This naturally increased considerably the volume of sewage to be pumped at that station and consequently the recurring expenditure on pumping. Laboratory experiments were therefore conducted to find whether the surplus activated sludge could be consolidated in the final settling tanks by isolating a few of them for the return sludge and the remainder for the consolidation of surplus sludge. Accordingly, out of the eighteen final settling tanks, six were set aside for the consolidation of surplus sludge and the remaining twelve for the return sludge required for injection purposes. The results of the experiments were very satisfactory and they proved that the surplus activated sludge could be consolidated and its volume reduced from about 1 m.g.d. to 50,000 gallons per day by consolidating for 6 hours in the six isolated final settlement tanks all the year round without impairing the quality of the effluent or giving any occasion for the sludge to rise to the surface. This method of consolidating excess activated sludge in some of the units of the final settling tanks is a new innovation and is worthy of incorporation in the design of an activated sludge plant.

Final settling tanks.—These units are generally designed on the same principles as those for sedimentation tanks. In American practice, circular tanks are popular and their design is based more on the surface area than on the volume. The overflow settling rate for circular tanks varies from 500 to 1,600 U.S. gallons per sq. ft. per day at mean flow. About 800 gallons per sq. ft. per day with detention period of 2 to 3 hours of average flow seems to be a good American design. Formerly, the diameters of these tanks were restricted to about 80 ft. but recently tanks of 130 ft. or more in diameter have been constructed. The average depth varies from 8 ft. to 14 ft. Engineers in England, Holland and Germany prefer rectangular tanks of the Dortmund hopper type with 60° slope. The usual size of this tank is 30 ft. square and provides for an upward velocity of 5 ft. per hour under maximum flow conditions while the vertical side depth is usually made equal to about $\frac{1}{8}$th of the side length. A detention period of 6 hours at dry weather flow is provided which corresponds to 2 hours at peak flow. The recent improvement in the construction of hopper is the rounding off the corners to a 4 ft. radius. At Mogden plant near London, a compromise tank has been constructed which is circular in plan and has a conical floor with a 30° slope. It provides for a maximum upward flow of 7 ft. per hour which corresponds approximately to 1,100 gallons per sq. ft. of tank area per day. The overflow weirs are usually of steel and are adjustable.

At Dadar, hopper type tanks have been constructed. They are 24 ft. square and allow a detention period of 4½ hours which is proposed to be reduced to 3 hours in future extension. It is desirable to provide mechanical apparatus for the removal of sludge from these tanks and a circular tank may be more advantageous for this purpose than an ordinary Dortmund type tank.

Flexibility.—In the Simplex Aeration Plant at Dadar an adjustable weir of 3 in. in height has been provided for the purpose of decreasing or increasing aeration. This height is so small that in actual practice it does not serve the purpose for which it is intended. It was also thought that increased aeration could be obtained by speeding up the aeration cones. One of the cones was therefore sped up from 39 revolutions to 49 revolutions per minute for a period of nearly four months, but no improvement was noticed either in the oxidation process or in the dissolved oxygen contents. The only way to increase the flexibility of this type of plant to withstand sudden variations in the character or volume of sewage is either by providing additional cones to be brought into use immediately when variations take place or by introducing air blowing in the first two cones so that the quantity of air to be blown in can be adjusted to suit the variations in the strength and volume of sewage passing through. This seems to be the logical solution of the problem as the B.O.D. demand of sewage is very much greater at its entry into the aeration cones and an increase in the air supply thereat would certainly enable the plant to deal with greater flows of varying strengths.

Tables III and IV give information regarding the progressive purification of sewage in various stages and the quantity of sewage treated, grit removed, etc., during the year 1941-42 respectively.

Digestion Tank.—Sludge digestion units at Dadar consist of three consolidation tanks, the digestion tank proper, pump house, two gasometers and sludge drying beds. Two kinds of sludges are to be disposed of—raw or primary sludge from the preliminary sedimentation tanks and the surplus activated sludge. Both of them are very obnoxious and create great nuisance and help fly breeding if dried in the open. Ordinary primary sludge is not so offensive in plants working in cold climates but due to its susceptibility to septicity and frequent removal in hot climates it has to be specially treated before drying in the open. Besides, its volume and quality are considerably different from those obtained in European plants. In order to reduce its volume, it is required to be consolidated from 98 to 95% water content before admission into the digestion tank. The primary sludge from Dadar plant is given quiescent settlement in consolidation tanks for at least 6 hours. The consolidated sludge deposited at the bottom of the tanks is pumped into the digestion tank.

Sewage Purification Works, Dadar.

Statement showing progressive purification of sewage in various stages—1941-42.

Year and Month.	Suspended Solids in			Percentage Reduction in sus. Solids from sewage to		4 hrs. Oxygen Absorption in			Percentage Purification. On 4 hrs. oxygen absorption from sewage to		B.O.D. of			Percentage Reduction. In B.O.D. from sewage to		Remarks.
	Sewage.	P.S. Tank. Effluent.	C.F.S. Tank. Effluent.	P S. Tank.	C.F.S Tank.	Sewage	P.S. Tank. Effluent	C.F.S. Tank. Effluent.	P.S. Tank.	C F.S. Tank.	Sewage. p.p.m.	P.S. p.p.m	C.F.S. p.p.m.	P S.	C.F.S.	
1941—																
April ..	46·3	12·8	16·1	72·55	65·23	7·95	4·22	4·65	46·92	41·51	297·4	167·9	210·2	43·47	29·23	
May ..	43·5	10·1	14·2	76·79	67·36	7·99	4·19	4·68	47·56	42·06	229·3	137·5	163·5	52·47	28·68	
June ..	41·6	12·1	15·2	70·23	63·46	8·26	4·14	4·63	49·88	43·94	242·7	158·4	181·4	34·72	25·26	
July ..	37·3	12·8	15·2	65·68	59·25	6·53	3·53	4·08	45·94	37·52	198·0	132·2	150·6	33·23	23·95	
August ..	39·6	16·0	18·2	59·60	53·94	7·17	4·86	5·20	32·22	27·48	240·2	173·7	196·5	27·65	18·15	
September ..	50·1	15·6	18·5	68·87	63·03	8·59	4·79	5·06	44·24	41·20	277·1	173·5	194·4	37·36	39·45	
October ..	44·3	14·0	18·6	68·4	58·02	7·57	4·09	4·72	45·98	37·65	271·0	162·2	178·7	39·45	40·15	
November ..	42·4	15·0	18·1	67·27	57·32	8·04	4·93	5·22	38·67	35·08	244·9	171·7	175·5	29·89	28·38	
December ..	56·8	18·0	25·6	68·31	54·93	9·29	5·24	6·05	43·49	34 89	299·6	202·0	229·2	32·58	23·50	
1942—																
January ..	60·3	21·0	26·1	65·18	56·72	9·45	5·60	6·01	40·75	36·41	335·8	227·1	266·7	32·38	20·55	
February ..	54·1	19·7	27·5	63·59	49·17	10·08	6·14	6·56	39·09	34·93	340·0	248·5	264·0	27·00	22·36	
March ..	50·2	18·8	22·1	62·55	55·99	8·87	5·58	5·66	37·10	36·19	294·1	211·3	215·5	28·16	26·73	
Average for the year 1941-42 ..	47·2	15·5	19·6	67·17	58·46	8·31	4·77	5·21	42·60	37·31	297·7	180·4	203·0	33·12	24·74	

P.S. Tank—Preliminary Settling Tank; C.F.S. Tank—Circular Settling Tank.
B.O.D.—Bio-chemical Oxygen Demand at 37°C in 5 days, expressed in p p.m. (parts per 1,000,000).

TABLE IV.

Sewage Purification Works, Dadar.

Statement giving information regarding quantity of sewage treated, grit removed, etc., during the year 1941-42.

From 1st April, 1941 to 31st March, 1942.

(1)	Sewage treated	4,158,57	million gallons.
(2)	Grit removed	1,37,802	cubic feet.
(3)	Screening removed	3,894	cubic feet.
(4)	Sludge to Consolidation Tanks ..	37,322,300	gallons.
(5)	Sludge to Digestion Tank ..	18,250,000	gallons.
(6)	Dry matter added to Digestion Tank..	7,469,150	lbs.
(7)	Volatile matter added to Digestion Tank	3,977,480	lbs.
(8)	Digested Sludge removed ..	2,600,000	gallons.
(9)	Total gas generated	25,367,908	cubic feet.
(10)	Gas per gallon of sludge added ..	1·39	cubic feet.
(11)	Gas per lb. of dry matter added ..	3·39	cubic feet.
(12)	Gas per lb. of volatile matter added ..	6·34	cubic feet.
(13)	Gas per 1,000,000 gallons of sewage treated	6,100	cubic feet.
(14)	Total electric consumption ..	750,380	kWh.
(15)	Horse-power required per million gallons of sewage treated ..	10·03	

		Rs.	A.	P.
(16)	Total Expenditure:			
	(*a*) Electric power	23,189	0	0
	(*b*) Salaries and wages fixed	26,097	0	0
	(*c*) Materials and supplies (Laboratory included)	4,839	12	0
	(*d*) Miscellaneous expenses . ..	9,685	0	0
(17)	Returns:—			
	(*a*) Sale of gas (5,253,600) . ..	16,059	12	0
	(*b*) Sale of manure	100	0	0

(18) Analytical Data:—

	Sewage.	Purified.	Effluent.
4 hrs. oxygen absorption	8·31	1·41	p.p. 100,000
Suspended solids ..	47·2	2·30	,,
Dissolved oxygen ..	Nil	0·16	,,
B.O.D.	269·7	18·6	p.p.m.

The supernatant liquid at the top is removed and mixed with the final effluent and discharged into the storm water drain. No mechanical appliances are used in the consolidation tanks to increase the solid contents and as a result thereof a sludge of about 4 to 5% solids is obtained. If, however, sludge thickener mechanism were used there would have been at least 8% solids in the sludge. It is proposed to incorporate mechanical sludge thickeners in the future extension of the consolidation tanks. The detention period of 6 hours is found to be adequate. Longer detention period is likely to help the fermentation of sludge affecting the separation of supernatant liquor. In the beginning, the consolidation tanks were kept open but it was found that the nuisance created by them from smell was intolerable and they

were therefore hermitically sealed with proper ventilators and manholes. Further additions, such as a level indicator, a top water level alarm bell and a scum breaker, appear to be necessary.

The digestion tank proper is of reinforced concrete, circular in plan with a hopper bottom and has an internal diameter of 63 ft. 6 in. and a total depth of 72 ft. It is provided with a floating roof of reinforced asbestos sheets, having a play of 12 ft. It can withstand a pressure of 5½ in. water gauge. In the centre of the roof a screw pump driven by vertical spindle, 20 B.H.P., is fixed for mixing the fresh sludge with digested and digesting sludge. The tank was designed for a capacity of 1 million gallons on the basis of 1·5 c.ft. *per capita* to provide a digestion period of 33 days. In English and American practice, tanks intended for primary sludge only have a capacity of between 1⅓ to 2 c.ft. per person while those dealing with primary plus surplus activated sludge have a capacity varying from 3 to 6 c.ft. per person. Some engineers fix the capacity on basis of per lb. of dry solids added daily or per lb. of volatile solids added daily. This gives a capacity of 15 c.ft. per lb. of dry solids and 21½ c.ft. per lb. of volatile solids for tanks digesting primary sludge only, and a capacity of 25 c.ft. per lb. of dry suspended solids and 36 c.ft. per lb. of volatile suspended solids for mixed sludge, i.e. primary plus surplus activated sludge. Correct information of the population draining to Dadar Purification Works is not still known, but on this basis the capacity at Dadar works out at 7 c.ft. per lb. of dry matter per day and 15 c.ft. per lb. of volatile matter added daily.

Owing to climatic conditions the process of digestion in cold countries is required to be sped up by resorting to artificial heating. Under normal atmospheric temperature varying from 50° to 60°F. in those countries, a long time is required for digestion and this requires tanks of large capacities. The most favourable temperature for mesophilic digestion lies between 77° and 86°F. though the optimum temperature appears to be somewhere near 98°F. Experiments at temperatures higher than 98°F. have been made and they have demonstrated that thermophilic digestion at 133° to 145°F. would be helpful in accelerating digestion, but it cannot be adopted on a large scale as it has some inherent drawbacks such as presence of odours and the consequent difficulty of getting rid of the supernatant liquor. Though heating arrangements were provided at Dadar for artificial heating, the climatic conditions in Bombay being favourable, no artificial heating was found necessary. The rate of generation of gas in all the three seasons of the year has been practically constant, except on some occasions in the monsoon when the intensity of rain was very heavy. The normal temperature in Bombay may be taken at 75°F. and its limit ranges from 63° to 93°F.

The gas generation on an average has been at the rate of 3·6 and 6·5 c.ft. of gas per lb. of dry and volatile matter added respectively. On the population basis it works out roughly to about 0·7 c.ft. per person draining to the disposal works. The gases generated are stored in two gasometers having a total capacity of 35,000 c.ft. The composition of the gas consists of 65% methane, 25 to 30% carbon dioxide, 2 to 5% nitrogen, 0·2% oxygen and traces of sulphuretted hydrogen. Its calorific value is found to vary between 600 to 650 B.T.U. per c.ft. These results compare favourably with those obtained at English, German and American plants.

The success of a sludge digestion tank depends upon thorough mixing of the added and digesting sludge. This is accomplished in some plants by mechanical means. Mechanical stirrers have not yet become popular as some engineers prefer to take advantage of the evolution of the gases inside the tank for mixing purposes. It has, however, been accepted that a mechanical apparatus is necessary at least for preventing the formation of scum on top if not for thorough mixing. The stirrer is not worked continuously but it is worked for about 5 minutes every 2 or 3 hours in a majority of plants. At Dadar, the mechanical stirrer is worked for 5 minutes every hour and is found to be effective in preventing scum formation.

The tank is worked on the constant level principle, i.e. whatever quantity of digested sludge or supernatant liquor is removed, an equal quantity is added. After a good deal of experimentation, a routine working has been arrived at. For six days in the week supernatant liquor is removed and an equal quantity of consolidated sludge is added, while on the seventh day of the week the digested sludge is removed and an equal quantity of consolidated sludge is added. The supernatant liquor is very obnoxious in character and contains about 50 to 90% of suspended solids on one hour's settlement. Formerly, it used to be added back to the activated sludge plant along with the influent, but it was found that it had an adverse effect on the performance of the plant. This practice was therefore discontinued. At Dadar, the supernatant liquor is discharged into the sea through the storm water drain. In places where easy methods for disposal of this liquor are not available, special treatment in specially prepared filters or sand beds is given.

When a digestion tank is to be started a good deal of forethought is required to be given; otherwise sludge having a tendency to get acidic day by day may make the contents of the tank acidic and thereby corrode the metal parts of the tank. For satisfactory digestion, the *p*H value of the sludge liquor in the digestion tank has generally to be maintained between 7·3 and 7·6. There are certain plants where satisfactory digestion is being carried on over a wide *p*H range varying from 6·6 to 7·8. This variation may probably be due to the nature of the wastes

admitted into the sewerage system and the establishment of a particular flora. It is usual in majority of the plants to start the tank by first filling it either with sludge or sewage, and in some cases by adding seedings from Imhoff or other tanks to accelerate fermentation.

A novel method was introduced in starting the tank at Dadar. The tank was filled with clear effluent from the purification plant before any sludge was added. This effluent has an alkalinity of about 22 parts per 100,000 and *p*H value of 7·6. Having filled the tank with this effluent, a comparatively small volume of 25,000 gallons of raw sludge was daily added and the same volume of supernatant liquor was removed. The *p*H was found to drop to a minimum of 6·8 instead of 5·5 as observed in many foreign plants. The reason for this appears to be the excess alkalinity always present in the non-putrescible effluent. It took about three months to bring the tank to proper working condition. In plants where suitable alkaline purified effluent is not available, it is suggested that instead of starting with acidic sludge or filling the tank with sewage which is potentially capable of becoming acidic on fermentation, the tank should be filled with sufficient milk of lime made up preferably with water, or where water is not available, with sewage. In the latter case, an extra quantity of lime should be added to neutralize acidic fermentation products of sewage itself. This procedure will prevent acid fermentation getting on top, avoid all smell nuisance even in early stages generally met with in the acid stage of fermentation, and what is more it will ensure smooth operation calculated to substantially reduce the strain on the nerves of the operator.

The plant has been satisfactorily working from 1937 and Table V represents the last year's working.

The digested sludge should be pitch black in colour, completely free from fly breeding and odour nuisance and should dry on sand beds in about seven days to about 30% moisture in tropical climate. Bacterial fermenting flora works very satisfactorily between 75° to 85°F. At 60°F. and below, artificial heating of digested sludge becomes necessary. Though originally the digestion tank was designed for a digestion period of 33 days, its working in the past four years has shown that 21 days' digestion would be quite suitable. Any further reduction will result in the deterioration of digested sludge.

Digestion considerably reduces the volume of the original sludge added to the tank. For instance, at Dadar for a sewage flow of about 5 million gallons per day, the digested sludge is about 50,000 gallons per week. Digestion also reduces its moisture content from 95 to 92%. The drying beds dry the sludge to a moisture content of 20 to 30% in seven days in hot season and ten days in winter. It can be safely dried in the open without creating smell or fly nuisance. In the rainy

season it cannot be dried on the beds but is discharged into the sea. In the extension plant provision has been made to pump the sludge to Deonar, a distance of about 10 miles, with a view to utilize the sludge for growing crops, and this scheme will form a part of the future scheme of the purification works to be installed for the southern and central areas drained at Love Grove. It is desirable, where plants are located in the midst of residential areas, to dispose of the sludge at a great distance so that in the case of breakdown of the plant or for any other reason no nuisance is created.

Some of the important designing features which require careful consideration in the new installation of a tank of this type are summarized below:—

(1) The floating roof should be made strong to withstand 12 in. water gauge pressure and should be preferably of steel. (2) The pressure valves on the pipes withdrawing supernatant liquor and digested sludge should be preferably preceded by hand-operated reflux valves to enable the former being repaired. (3) A plant should be installed to remove the traces of sulphuretted hydrogen from the gas, as it has an adverse effect on the pipe line used for its conveyance. At Dadar, a sulphuretted hydrogen removal plant has lately been added but it has not yet been brought into operation. (4) All gas pipe lines should be laid at ground level preferably through a concrete channel to facilitate maintenance. (5) All drain pipes and blow off vents on the gas pipe lines should be located in the open to prevent accidents due to the explosive character of the gas. (6) Where local conditions warrant, the inlet and outlet pipes from the gas-holders should be on the top so as to make them easily accessible for repairs. (7) Properly designed flame traps, waste gas burners, syphon boxes for condensed water should be provided at all essential points on the gas pipe lines. (8) It may also be desirable to take into consideration the principle of multiple-stage digestion as it is found to be economical in working at some of the English and American plants This point also has been borne in mind in the extension of the Dadar plant.

Utilization of gas.—The total quantity of gas obtained from the digestion tank is about 60,000 c.ft. per day out of which about 15,000 c.ft is being used at present for cooking and heating purposes mainly at the K.E.M. Hospital, and the rest has unfortunately to be burnt to waste. Before the sludge gas could be used in the Bunsen burners and the geysers, their design had to be modified as the sludge gas is rich in calorific value than coal or town gas and has different burning characteristics due to difference in the speed of flame propagation. Ordinary Bunsen burners would blow off as soon as they were lighted. The flame temperature was low and crucible work in the laboratory was not possible. A standard type Bunsen burner working with sludge gas has now been evolved for use in the laboratory. The

burners of the geysers were also modified for working with sludge gas.

The possibility of using sludge gas for street lighting was also investigated. It is found that the normal coal gas lamps burn fairly satisfactorily with sludge gas, but with about 20% less efficiency, as far as luminosity is concerned. Their pilots get choked up rather frequently. Their mantles get brownish yellow deposits on them. It is proposed to make further investigations in this connection at the end of the war.

A scheme for compressing this gas to 5,000 lb. per sq. inch and filling it in cylinders for the purpose of utilizing it for lorry running as a substitute for petrol is under trial, and it is hoped that a lorry working on sludge gas will be running on the streets of Bombay shortly. The technique of lorry running on sludge gas is very complicated and as the lorry has not yet been run it is not possible at this stage to give any information regarding the same. Experiments are going to be made shortly to find whether sludge gas can be used for cutting and welding as a substitute for oxyacetylene gas.

Enclosed forced draft filter.—The enclosed draft filter at Dadar is a R.C.C. circular chamber 78 ft. 6 in. in diameter with sloping conical roof. The filter is filled with 4 ft. of crushed metal from ¾ in. to 2½ in. size at the bottom, and 8 ft. of clinker of different sizes from 1½ in. to 6 in. on top of the metal making the total depth of filtering media 12 ft. In the centre of the roof an electric fan capable of delivering from 7,000 to 12,000 c.ft. of free air per minute at 2 in. to 1 in. water gauge pressure has been installed to supply the required quantity of air to the biological life which thrives on the filter media and carries out the work of liquefaction. A reaction type multiple arm rotary distributor is located in the centre of the filtering media for even distribution of pre-settled sewage on the filter. The settled sewage then percolates through the media and is purified during its downward passage by a variety of biological life. A humus tank, 36 ft. in diameter, is installed in conjunction with this filter to arrest humus before discharge of the effluent into the open storm water drain.

The main idea underlying the installation of this filter was (1) to compare its working in respect of performance as well as recurring expenditure with the Simplex Activated Sludge Process already in operation, (2) to ascertain whether it could be used as an intermediary between the preliminary sedimentation tanks and the activated sludge plant so as to lighten the load on the latter and to make it work more as a final polishing process than as a main process for the oxidation and nitrification of sewage, and (3) to ascertain its claim of freedom from smell and fly nuisance.

It was expected that the filter would be able to cope with a flow of 2 m.g.d. after it was properly matured. This would

give a rate equal to 18 times that of an open type percolating filter with a depth of 6 ft., viz. 1 m.g.d. per acre per day.

The maturing period may be as long as one year. At Dadar, the filter was started by feeding it with the purified effluent of the activated sludge plant instead of the usual method of starting it with settled sewage. It took about four weeks to reach the nitrification stage. When nitrification stage was established, the filter was gradually charged with settled sewage, i.e. with the effluent from the preliminary sedimentation tanks. The feeding was kept constant for about a fortnight and afterwards increased very gradually to 1 m.g.d. without allowing the effluent to deteriorate. This rate of application was continued for about a month and then the feed was suddenly increased to 2 m.g.d. This completely upset the working of the filter which was noticed in the deterioration of the quality of the effluent. This proved the desirability of increasing the load on the filter gradually and not suddenly as was done at this stage. Attempts made to regenerate the filter by reducing the load to 1 m.g.d. also failed. The filter had therefore to be started *de novo*. When the flow was being treated satisfactorily at 1 m.g.d., typical psychoda fly was thriving on the filter in swarms and small red riggling worms as well as earthworms were noticed coming out with the effluent in large numbers. It was feared that proper typical psychoda fly as seen in foreign filter plants would not breed in Bombay and that it may be necessary to introduce it into the filter from outside. It was, however, found that psychoda fly did breed of its own accord in the body of the filter and that it had practically the same life-history as that in foreign plants. Careful observations on the presence of psychoda fly in the body of the filter has shown that for 3 to 4 months of the year, say from October to February, its occurrence is slightly reduced and during the rest of the year it is thriving abundantly. It is also noticed that during the period the life is reduced, no deterioration in the quality of the effluent takes place. The humus collected at the bottom of the tank gave good settlement, but as soon as the feed was suddenly increased to 2 m.g.d., the humus was very offensive and the psychoda fly disappeared completely. Observations on 'ponding' showed that at the end of about three months' working and before the establishment of the proper biological life, the entire surface of the filter got choked. Chlorination was resorted to by stopping the filter for a couple of days but it had no appreciable effect in removing 'ponding'. The filter was therefore re-started, and in about three weeks' time, the psychoda fly made its appearance in large swarms and the ponding automatically disappeared in a couple of days.

It was considered essential to give some resting period to the filter for satisfactory performance though opinion in this regard varies. In the beginning, four hours' rest was given at the end

of every week by stopping the feed of settled sewage as well as air during this period. It was found that more rest was necessary. After a good deal of experimenting, 2 to 4 hours' rest per day was arrived at for satisfactory working. The resting period is helpful to the psychoda fly to come to the surface and for breeding.

The filter was started *de novo* and the load is being gradually increased. It has again come to 1 m.g.d. and it is hoped that the original anticipation of treating 2 m.g.d. may be realized in about a year's time. The results of the working of the filter can be seen from Table VI.

It is also noticed that the capacity of the humus tank provided for in the original design is inadequate for a rate of 2 m.g.d. Steps have therefore been taken to duplicate this unit.

Observations regarding the working of the existing activated sludge plant as a final polishing process have not yet been possible. There is, however, no doubt that the filter has proved its claim as regards prevention of odour and fly nuisance.

As there are no arrangements for measuring the quantity of air at Dadar, no relation could be found between the quantity of forced draft and the purification obtained. There is, however, reason to believe that the volume of air passing through the filter is sufficiently large as the analysis of the outgoing air from the filter neither showed any increase in CO_2 nor deficiency in oxygen. This has been to some extent confirmed by the observations carried out on the filter for the past two months when it worked without any forced draft. An opportunity for testing its performance without forced draft presented itself accidentally due to the burning out of the electric motor working the fan supplying the air and the difficulty of replacing the same immediately due to war conditions. It was from the very beginning felt that blowing in air was not necessary for all the flows and that natural ventilation through the small top opening of the roof could be relied upon to supply air required for purifying a certain flow of sewage due to favourable temperature conditions prevailing in Bombay, though the general experience of European workers in this field is that in the absence of forced air draft the effluent from the filter deteriorates rapidly.

The filter worked without forced draft from the 18th of October with a flow of 0·75 m.g.d. The results of its performance are very encouraging as can be seen from the results of the analyses of the effluent given in Table VII. The analyses show that there has been no deterioration of the effluent as judged by the usual standards of purification. In fact, the monthly average figures for percentage purification with and without forced air draft have remained practically the same and of a higher order on four hours' oxygen absorption, suspended solids, B.O.D. and albuminoid nitrogen. The only difference noticed was the fall in the presence of nitrites and nitrates in the effluent as compared with that of the preceding months when the fan

-Filter Plant. Dadar. Results in parts per 100,000.

Pruss-Filter operating at 0·75 m.g.d. *With Forced-air.*

For the month of September, 1942.

[W]eek [ending] 5th.	2nd Week ending 12th.		3rd Week ending 19th.		4th Week ending 26th.		Monthly average.		Remarks.
Effluent.	Influent	Effluent.	Influent.	Effluent.	Influent.	Effluent.	Influent.	Effluent	
2·03	12·4	2·19	13·0	2·0	16·0	2·4	12·9	2·16	Percentage purifications: for the month of September, 1942.
0·44	..	0·31	.	0·43	..	0·49	..	0·42	Four hours' oxygen absorption: 70·6.
1·06	3·99	1·10	3·71	1·08	4·99	1·49	4·02	1·18	Suspended solids: 83·3. Alb. nitrogen: 78·5.
5·8	136·0	11·2	143·0	10·7	135·0	4·4	121·9	8·0	B.O.D.: 93·4.
18·2	..	21·4	..	19·2	..	18·2	..	19·3	Volume of air supplied by the fan on top is not actually measured but the capacity of the fan varies from maximum 12,000 c.ft. to a minimum of 7,000 c.ft. of air per minute. This forced air issues out from the *bottom* of clinker.
8·5	..	10·4	..	10·2		12·0	..	10·3	
0·016	0·40	0·032	0·76	0·032	0·92	0·08	0·625	0·04	
0·039	0·12	0·03	0·26	0·049	0·29	0·053	0·20	0·043	
7·9	..	8·0	..	8·1	..	7·9	..	8·0	
0·029	..	0·009	..	0·033	..	0·034	..	0·026	
0·50	..	0·55	..	0·90	..	0·72	..	0·67	
0·46	.	0·49	..	0·46	..	0·38	..	0·45	
	0·75		0·75		0·75		0·75		
	20		20		20		20		
	4		4		4		4		

supplying the air was working. This indicates that nitrogen oxidation is more active in the presence of forced air. This view is also supported by the figures of free and albuminoid nitrogen which are always less with purified effluent with forced air as a result of greater breaking down of the complex nitrogenous compounds in sewage. The dissolved oxygen contents are also considerably greater with forced air. The only disadvantage with the flow of 0·75 m.g.d. appears to be that of the presence of foul air in the close proximity of the filter. It would therefore appear that a closed filter without forced air may not be suitable for places where good oxidation and absence of foul odour are essential. It should be noted, however, that the figures in the Table for the months of September and November cannot be compared directly as the strength of sewage varied considerably in the two months; in fact, sewage was stronger in November when the filter worked without forced draft. It is intended to carry on these observations for a considerable period and to gradually increase the flow to ascertain the maximum quantity per day that can be treated satisfactorily without forced draft.

Some modifications in the present design are considered necessary. There are at present 40 fixed glass panes in the circular wall all round the media for the purpose of inspection and admission of sunlight. Both these objects do not appear to be fulfilled by these windows as the spray of sewage and the subsequent organic growth entirely covers the glass panes. In order to facilitate the work of inspection and repairs, it is necessary to provide electric lighting inside the filter. The side doors cannot be used for light repairs and in order to facilitate such kind of repairs it is necessary to have additional access to the inside of the filter from the roof.

The portholes provided at the bottom to serve as outlets for used up air should be sloped inwards to prevent sewage being blown out as a spray and thereby create unsightly conditions and fly breeding. It is desirable to connect these portholes to a closed conduit and discharge the foul air so collected at a height of 30 to 40 ft. in the atmosphere.

The working of the filter has shown that it has a definite advantage over the activated sludge plant: (1) It requires 15 to 18 h.p. per million gallons whereas activated sludge process requires 28 to 35 h.p. per million gallons. (2) The mechanical attention required is much less and the mechanism is less complicated than that in the activated sludge process. (3) Skilled supervision is not constantly required due to non-sensitiveness. (4) Manual labour required for its upkeep is less than that for the activated sludge process. (5) For equal capacity plants the area required for an enclosed filter is almost half of that required for activated sludge plant.

Laboratory control.—A modern sewage works cannot be operated satisfactorily without the provision of a suitable

laboratory under the control of a highly qualified chemist. In addition to the consulting engineer and the mechanical operator, the chemist has to play his part especially when the works include activated sludge process and a digestion tank. In the case of activated sludge process, wrong handling means smell nuisance whereas in the case of digestion tank gases form a very explosive mixture with air and great care is required in its working. There are certain routine observations and tests which must be carried out every day. In short, the responsibility of the staff handling the plants is necessarily very great and the laboratory is the most valuable unit of the plant. Depending upon the size of the plant, the laboratory should be equipped to enable investigations of problems for future extensions and planning being carried out. At large plants, the laboratory should be highly equipped to undertake higher research work. A good deal of research work still remains to be carried out in this country to find out how the various processes followed in other countries can be adapted to suit local conditions, the character of sewage and climate. It is only by research work in such laboratories that the most economic and suitable solution of the problem can be obtained. The laboratory and the works at Dadar are under the management of Mr. Y. N. Kotwal, B.A., B.Sc., M.I.S.P., A.I.I.Sc., and the observations made thereat and the investigations carried out have been helpful in correcting the impressions formed from the reading of textbooks and the working of the plants in foreign countries. They have also contributed towards the solution of the sewage disposal problem of the central parts of the city, which is receiving the attention of the Corporation for the past 30 years. I take this opportunity of thanking Mr. Kotwal and the members of the laboratory for the valuable help that I have received from them in the design and operation of Dadar Purification Works.

General principles of design.—Before I conclude, a few observations on the design of sewage disposal works based on personal experience will not be out of place. The first point that should receive the attention of the designing engineer is the degree of treatment required to satisfy particular conditions. It is seldom that treatment works are designed to purify sewage completely. The objective aimed at, in most of the works, is the removal of impurities contained in sewage at the least cost consistent with the requisite degree of treatment. If dilution is the method of disposal, complete information in regard to stream flows, use of water by lower riparian owners, the capacity of the receiving stream to take care of pollution loads should be collected. The next point is the determination within reasonable limits of the quantity and quality of sewage to be treated and the probable effects of the industrial wastes discharged into sewers on the treatment works. Having determined the type of treatment, the next decision should be in regard to the location of the

treatment works. The site selected should be as far away as possible from thickly populated areas and it should be sufficient in extent to allow for reasonable isolation and future extensions. The three major essentials in the design should be simplicity, flexibility and convenience from the operation point of view. Increase in complexity invariably increases the number of points where trouble may occur. This has an adverse effect on small plants as sufficient number of men with adequate qualifications is hardly available to locate the cause of all troubles or to correct them when discovered. It is difficult to visualize the problems of operation in the planning stage, but where greater attention is paid to this aspect of the design, it has resulted in increasing economy and efficiency of the plant as well as safety of operation and maintenance. It should be remembered that even the best design fails to work properly without the co-operation of a willing operator. 'Flexibility' is equally important. The plant should be flexible to supply air and return sludge at variable rates in accordance with the demand of sewage. There should also be more than one point to which wet sludge may be discharged. The by-passing of certain units to cope with the variation of loading should be provided for in all the plants. Duplication of units for alternate methods for accomplishing the same results are essential where mechanical units are subject to breakdown. Mechanical equipment, such as pumps, screens, and heating devices, must be accessible for repairs and overhauling. Points of lubrication must be easy to get at. Lighting should be provided at all important locations. Mechanization is very useful and necessary in large plants but in smaller plants it is both costly and unnecessary.

Additional units for preliminary sedimentation should be provided for being brought into use in the rainy season as a large quantity of rain and subsoil water finds its way into the sewers. The dilution of sewage with rain water helps the purification process but impedes the settlement of suspended solids in the preliminary sedimentation tanks as large quantities create greater velocities which carry the suspended solids to the aeration tanks. These units will also be helpful in the cold and dry months when repairs or overhauling are required to be carried out to the preliminary sedimentation tanks.

Pipes intended for the conveyance of sludge should be of ample size and of the shortest possible length from the point of entry to the point of discharge. Straight runs are mostly desirable. Where bends are required, they should be made through plugged tees to enable rodding or flushing, if clogging occurs.

All steel parts exposed to sewage and sewage gases should be protected from corrosion either with good paint or concrete, otherwise they are likely to get badly corroded. At Dadar, many paints were tried to prevent corrosion but none of them has

stood the test even for six months. It seems that a paint which can withstand corrosive action of sewage is yet to be manufactured. In its absence, the only effective coating worth the expense is concrete. It is no doubt costlier than a paint, but it preserves steel for a longer period and saves the recurring expenditure.

Reasonable degree of beautification and landscaping is highly desirable. This can be achieved by planting some trees on boundaries and providing lawns and some creepers to conceal unsightly structures. This does not require much expenditure.

Sewage disposal is a universally repugnant subject and the public conclude that a sewage treatment plant cannot but be a place of foul odours and obnoxious sights, a place only fit for scavengers, a place which must be avoided by respectable persons. A well-arranged, clean and landscaped sewage works has a favourable psychological effect on the workers and visitors. The public will then know that, at a sewage treatment plant, even men, both clean and intelligent like themselves, are working, doing an important job and recovering useful products from human waste.

In short, the functions of designing should be to provide the degree of treatment desired, of the quantity and quality of sewage anticipated, at the most reasonable cost of construction with the greatest possible facility of operation and with the greatest safety to the operating staff.

APPENDIX

Definitions

(1) *Flocculation.*—Flocculation is the coagulation or coalescence of colloidal and very finely suspended matter, normally unsettlable, brought about chemically by the addition of some chemicals like alum or mechanically by slow stirring or agitation of sewage by paddles or compressed air.

(2) *B.O.D.*—B.O.D. is an abbreviation of the term Biochemical Oxygen Demand of sewage or polluted water and means the oxygen in parts per million required during stabilization of the decomposable organic matter by aerobic bacterial action.

(3) *m.g.d.*—m.g.d. is million gallons per day and refers to the flow of sewage in 24 hours expressed in gallons.

(4) *Clarification stage.*—Clarification stage is a particular limit or stage in the purification of sewage wherein the purification proceeds to a point of being rendered clear on settlement but not oxidized to a stable non-putrescible effluent.

(5) *Nitrification stage.*—Nitrification stage is the purification of organic matter in the sewage to a final stable effluent by

breaking down the complex organic nitrogenous products and oxidizing them to innocuous stable inorganic products like nitrates and nitrites.

(6) *Tapered aeration.*—Tapered aeration is aeration of sewage in a manner such that more air is supplied in the early stages of aeration and reduced air at the later stages of purification when the demand for oxygen is reduced. In short, tapered aeration is gradually reduced supply of air to suit the increasing purification.

(7) *'Conditioner' of sludge.*—'Conditioner' of sludge is a term used in the filter-pressing of sewage sludge and is applied to any chemical or a mixture of chemicals added to the sludge to render it more suitable for filter-pressing by separating its water or by rendering it more granular.

(8) *To elutriate.*—To elutriate is to wash the raw sludge by clean water or clear effluent so as to dissolve out some interfering constituents which render the sludge either impossible or difficult to filter-press.

(9) *Mesophilic digestion.*—Mesophilic digestion is the fermentation of sewage sludge at a temperature of about 75° to 85°F.

(10) *Thermophilic digestion.*—Thermophilic digestion is formentation of sewage sludge at a higher temperature somewhere about 110° to 145°F.

(11) *Free nitrogen.*—Free nitrogen is the nitrogen present in sewage and sewage-polluted waters in the form of ammonium salts and which could be distilled off by boiling the sample as such or after neutralization if the sample is acid in reaction.

(12) *Albuminoid nitrogen.*—Albuminoid nitrogen is the nitrogen present in the form of complex nitrogenous organic compounds. This nitrogen can only be distilled as ammonium hydroxide in the presence of strong alkaline potassium permanganate.

(13) *Four hours' oxygen absorption.*—Four hours' oxygen absorption means the actual absorption of oxygen from an acid permanganate solution by the oxidizable matter present in the sewage sample in the form of both solution and solids in a period of four hours at the normal laboratory temperature. This indicates in a general way the strength of the sewage.

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PART III—ABSTRACTS

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SECTION OF MATHEMATICS AND STATISTICS

President:—S. C. Dhar, D.Sc. (Cal. & Edin.), F.R.S.E., F.N.I.

Algebra

1. Two algebraic identities of higher differences.

S. C. Chakrabarti, Jadabpur (Bengal).

The author obtains the following two identities:—

If $\left[\begin{matrix} n \\ c \end{matrix}\right] = (a^n-1)(a^{n-1}-1)(a^{n-2}-1)\ \ldots\ (a^c-1)$

and ${}^nS_x$ = sum of the products of n factors $1, a, a^2, a^3, \ldots a^{n-1}$ taken x at a time, then

$$\text{(i)}\quad \sum_{x=0}^{n} (-)^x \frac{a^x}{a^{x+1}-1}\, {}^nS_x = \frac{1}{a^{n+1}-1}$$

and
$$\text{(ii)}\quad \sum_{x=0}^{n} \frac{a^{\frac{1}{2}x(x+3)}}{\left[\begin{matrix} 1+x \\ 1 \end{matrix}\right]\left[\begin{matrix} n-x \\ 1 \end{matrix}\right]}\, {}^nS_x = \frac{1}{\left[\begin{matrix} n+1 \\ 1 \end{matrix}\right] {}^nS_n}\, {}^{2n+1}S_n$$

2. On a linear Boolean Ring of n-dimensions.

Ramavtar Shukla *and* P. N. Das Gupta, Patna.

M. H. Stone had discussed two dimensional Boolean Rings (*Transactions, American Mathematical Society*, July 1936). The author assumed certain definitions regarding addition and multiplication. The present paper extends the properties there discussed to n-dimensional rings and includes some properties regarding regularity and division.

3. Lattice sums of cubic crystals.

Rama Dhar Misra, Lucknow.

If a be the lattice constant of the undeformed cubic lattice then the distance ρl of the point (l_1, l_2, l_3) from the point (0, 0, 0) is given by

$$(\rho l)^2 = a^2\left(l_1^2+l_2^2+l_3^2\right)$$

Here l_1, l_2, l_3 are always integral, positive or negative.

In order to explain the phenomena of stability, melting, tensile strength, etc., we require lattice sums of the type

$$S_n^{(k_1,\,k_2,\,k_3)} = \sum_l \frac{l_1^{2k_1} \cdot l_2^{2k_2} \cdot l_3^{2k_3}}{\left(l_1^2+l_2^2+l_3^2\right)^{\frac{1}{2}n}}$$

the summation to extend over all possible positive and negative integral values of l_1, l_2, l_3 excepting $l_1 = l_2 = l_3 = 0$. n is positive integral.

Some of these sums have been calculated for certain values of n by the author. The present paper consists of an improvement upon the method used previously. We can calculate the upper and lower limits for the error committed in taking the approximation at any stage and thus we can obtain the lattice sums correct to any desired degree of accuracy.

Geometry

4. Normal rectilinear congruences.

RAM BEHARI, Delhi.

In this paper a property of normal rectilinear congruences has been obtained.

5. On a certain variety V_n^n in $[2n]$

B. RAMAMURTI, Ajmer.

In a paper published by the author (a generalization of the null pencils of binary quartics. *Jour. Lond. Math. Soc.*, 13, 1938) a correspondence is established between points in $[n+1]$ and certain special $[n-1]$ s of $[2n]$. The object of this note is to prove that in this correspondence to a line in $[n+1]$ corresponds a rational normal variety V_n^n in a prime of $[2n]$. Such varieties as V_3^3 in [6] are studied in detail.

Analysis

6. On a non-differentiable function.

UMA KANT SHUKLA, Lucknow.

In this paper the author has defined two numbers x and $y = f(x)$ such that the function $f(x)$ is non-differentiable for all values of x in (0, 1). In defining x and y he has used decimal scale which is most familiar. This scale has not been used before in defining such functions. Proofs of continuity and non-differentiability of the function along with sets of points, where it possesses progressive or regressive derivatives have been given.

7. Differentiability of monotone functions.

P. D. SHUKLA, Lucknow.

In this paper a necessary and sufficient condition for the differentiability of monotone functions has been found out. This condition has been utilized to study the existence of the differential coefficients of integrals.

8. Note on a theorem of Hardy and Littlewood concerning the Cesàro summability of the conjugate series of a Fourier series.

B. N. PRASAD, Allahabad.

In this paper an investigation has been made as to the *necessary and sufficient* condition so that the conjugate series of a Fourier series may be

summable almost everywhere by every Cesàro mean of positive order. The theorem proved is that in a point of the Lebesque set, the necessary and sufficient condition that the conjugate series be summable (C, δ) for every $\delta > 0$, is that the conjugate function exists at least as a non-absolutely convergent Cauchy integral at that point.

9. The maximum term of an entire series.

S. M. SHAH, Aligarh.

Let $\mu(r)$ be the maximum term, for $|z| = r$, of the entire series $f(z) = \sum_{0}^{\infty} a_n z^n$ and $\nu(r)$ its rank. The author proves the following two theorems:—

Theorem 1. If $f(z)$ be of order ρ, $0 \leqslant \rho \leqslant \infty$ then

$$\liminf_{r\to\infty} \frac{\nu(r)}{\log \mu(r)} \leqslant \lambda \leqslant \rho \leqslant \limsup_{r\to\infty} \frac{\nu(r)}{\log \mu(r)}$$

where λ is the lower order of $f(z)$.

Theorem 2. If $f(z)$ be of order ρ, $0 < \rho < \infty$ then

$$\limsup_{r\to\infty} \frac{\nu(r)}{r^\rho} \geqslant \rho \limsup_{r\to\infty} \frac{\log M(r)}{r^\rho} \geqslant \rho \liminf_{r\to\infty} \frac{\log M(r)}{r^\rho} \geqslant \liminf_{r\to\infty} \frac{\nu(r)}{r^\rho}.$$

10. On meromorphic functions of order less than one.

S. M. SHAH, Aligarh.

The main results proved in this paper are:

Theorem 1. If $f(z)$ be a meromorphic function of order ρ, $0 \leqslant \rho < 1$ then

$$\liminf_{r\to\infty} \frac{T(r)}{N(r, a)+N(r, b)} \leqslant \frac{1}{1-\rho}$$

where $a \neq b$ are any two numbers.

Theorem 2. Let $f(z)$ be a meromorphic function of zero order. If $n(r, 0) \sim A(l_1 r)^{\alpha_1} \ldots\ldots (l_k r)^{\alpha_k}$ and $n(r, \infty) = 0(n(r, 0))$ then

$$\lim_{r\to\infty} \frac{T(r)}{n(r, 0) \log r} = \frac{1}{1+\alpha_1}$$

11. Some integrals involving Humbert function.

B. R. PASRICHA, Lucknow.

In this paper several integrals involving Humbert function defined by

$$J_{m, n}(x) = \frac{x^{m+n}}{3^{m+n} \lfloor m+l \lfloor n+l} {}_0F_2\left(m+l, n+l; -\frac{x^3}{27}\right).$$

have been investigated by the method of Heaveside's operational calculus. It is interesting to note that the method gives pretty general results.

12. An infinite integral involving Whittaker's function.

R. S. VARMA, Lucknow.

The object of this paper is to investigate an infinite integral involving Whittaker's function $\omega_{k,m}(z)$. The method adopted is that of integration by parts.

13. On certain infinite integrals involving Whittaker and other functions.

S. C. DHAR, Nagpur.

The author studies certain infinite integrals involving Whittaker and other functions and obtains certain contour integral forms for the ω-functions.

14. Infinite integrals involving Bessel functions.

B. MOHAN, Benares.

The two main results are:

$$\int_0^\infty x^{p-1}e^{-ax^2}I_\nu(bx)\,dx = \frac{b^\nu\Gamma(\frac{1}{2}\nu+\frac{1}{2}p)}{2^{\nu+1}a^{\frac{1}{2}\nu+\frac{1}{2}p}\Gamma(\nu+1)}\,{}_1F_1\left(\tfrac{1}{2}\nu+\tfrac{1}{2}p;\ \nu+1;\ \frac{b^2}{4a}\right),$$

where $R(\nu+p)>0$, $R(a\pm b)>0$;

$$\int_0^\infty x^{p-1}K_m(ax)\,I_n(bx)\,dx$$

$$=\frac{2^{p-2}\Gamma(\frac{1}{2}n+\frac{1}{2}p+\frac{1}{2}m)\Gamma(\frac{1}{2}n+\frac{1}{2}p-\frac{1}{2}m)b^n}{a^{n+p}\Gamma(n+1)}$$

$$\times F\begin{pmatrix}\frac{1}{2}n+\frac{1}{2}p+\frac{1}{2}m, & \frac{1}{2}n+\frac{1}{2}p-\frac{1}{2}m\\ n+1; & \dfrac{b^2}{a^2}\end{pmatrix}$$

where $R(p+n)>R(m)$, $R(a\pm b)>0$.

and I, K denote Bessel functions of imaginary argument of the first and second kind respectively.

15. Some definite integrals involving Bessel functions.

H. C. GUPTA, Cawnpore.

The object of this paper is to evaluate some infinite integrals involving Bessel functions.

16. On the differential equation $f^r(x)=f^s(1/x)$.

G. R. SETH, Delhi.

The solution of $f^r(x)=f^s(1/x)$ has been discussed in this paper. A particular case of this equation obtained by putting $s=0$ has been discussed by P. N. Sharma in a paper shortly to be published. An interesting feature of this equation is that the complete integral of $f^{r-s}(x)=f(1/x)$ or of $f(x)=f^{s-r}(1/x)$ is a particular solution of $f^r(x)=f^s(1/x)$ according as $r>$ or $<s$.

Hydromechanics

17. Fluid motions of the type $\xi_1 = \lambda_2 u_2$, etc., and $\xi_2 = \lambda_1 u_1$, etc.

RAM BALLABH, Lucknow.

In the paper 'Superposable Fluid Motions', published in the *Proceedings of the Benares Mathematical Society*, Vol. II, New Series (1940), it has been shown that two motions in which the vortex lines of one coincide with the streamlines of the other can be superimposed upon one another so that the resulting velocity is the sum of the two velocities. In this paper such motions have been discussed.

An extension of Bernoulli's theorem has been obtained for a class of these motions and they have been shown to exist by choosing a particular case of uniplanar motions.

18. On some cases of flow of a compressible fluid past an obstacle.

D. N. SEN *and* D. N. LAL, Patna.

Rayleigh discussed the flow past a circular cylinder, without circulation of the fluid round it, by a method of successive approximation. Lamb generalized the case by including circulation for which the functional form becomes

$$\omega = -V\left(z + \frac{a^2}{z}\right) - ic \log z,$$

as the first approximation (*Bull. Cal. Math. Soc.*, XX).

The object of the paper is to apply the method to motions given by some other functional form.

19. On the stress-strain velocity relations in equations of viscous flow.

B. R. SETH, Delhi.

Most of the mathematical results obtained for the motion of a viscous liquid are subject to serious limitations. More often than not we neglect the inertia terms. But even when it is possible not to neglect such terms the ordinary theory does not give satisfactory results in the case of many liquids we have got to deal with in everyday life. In fact non-Newtonian liquids, i.e. those in which the rate of shear is not proportional to the shearing stress, do not obey Poiseuille's or Stoke's law. It may therefore be of some interest to work out the consequences of a change in the stress-strain velocity relations. The method adopted is to include in these relations second degree terms without changing their tensor form. One result of such a change is that we get limits outside which a particular assumed character of the motion cannot be maintained.

Astronomy and Astrophysics

20. The Laghu-Bhāskarīya—A Hindu astronomical work of the sixth century A.D.

A. N. SINGH, Lucknow.

The *Laghu-Bhāskarīya*, an astronomical work, written by Bhāskara, with a commentary by Śaṅkara Nārāyaṇa is being published at Lucknow and will be out soon. The astronomer Bhāskara flourished in the sixth century. He has been placed in 522 A.D. by Bibhutibhusan Datta, which is probably the date of composition of another work of this author

called *Karmanibandha* or the *Mahā-Bhāskarīya*. This Bhāskara flourished long before the famous Bhāskarācārya who wrote the *Līlāvatī* in 1150 A.D. The commentator Śaṅkara Nārāyaṇa gives his own date as *Śaka* 791 which corresponds to 869 A.D.

Besides the above work two other works by the same author, the *Mahā-Bhāskarīya* and a Commentary on the *Āryabhaṭīya* are in our possession. They will be published in due course. The *Laghu-Bhāskarīya* claims to give in short an exposition of Āryabhaṭa's system of astronomy.

The commentator Śaṅkara Nārāyaṇa was an inhabitant of Kollapurī, the modern Quilon. He mentions at several places Ravivarmadeva Kulaśekhara, a king of the Kerala country. Mahodayapura was probably his capital, as mentioned in one of the examples. According to the statements made in the commentary, Ravivarmadeva died in 844 A.D. He seems to have been the author of a work on astronomy.

The Kerala country has been for a long time a seat of astronomy and mathematics. To the Kerala school of mathematics belonged such illustrious mathematicians and astronomers as Parameśvara, Nīlakaṇṭha, Talakulanthurā nambuttirī, and probably Mahāvīrācārya and our author Bhāskara.

It is of immense importance for the history of mathematics and astronomy in India, for this is the earliest book available to us which gives in detail the calculations involved in Āryabhaṭa's astronomy.

21. The approximate homogeneity of the Cepheid variable.

H. K. SEN, Allahabad.

It has been shown that no radial mode of oscillation is possible for a model in which the law of density can be represented by a finite polynomial. The conclusion has been drawn that radial oscillations can only be possible for the homogeneous star. An explanation has been offered of the observed predominance of the fundamental mode of radial oscillation, and the bearing of the result on the origin of the solar system (with particular reference to Banerji's Cepheid theory) and of the double stars has been indicated.

22. Radial oscillations of the generalized Roche's model.

H. K. SEN, Allahabad.

For small radial oscillations of the generalized Roche's model, it has been found that the radius of the nucleus must bear certain defined ratios to that of the whole sphere, and that only one mode is possible for a particular value of the ratio. The bearing of this on the origin of the spiral nebulae has been considered. The generalized Roche's model has, further, been shown incapable of large radial oscillations.

23. The rotating Cepheid.

H. K. SEN, Allahabad.

It has been shown that the oscillations of a rotating star will not remain purely radial for an angular velocity of rotation great enough for the retention of the terms of the order of the square of the mean ellipticity of the pseudospheroidal surface. The bearing of this on Cepheid oscillation and on Cosmogony has been touched upon.

SECTION OF PHYSICS

President :—H. J. BHABHA, F.R.S.

Nuclear Physics and Cosmic Radiation

1. The atmospheric absorption curves and their dependence on the nature of the primary cosmic rays.

S. K. CHAKRABARTY, Calcutta.

With a view to testing the possibility of interpreting the observed results on the absorption of cosmic rays in the atmosphere in terms of incoming electrons or positrons, the nature of the absorption curves produced by soft primaries has been calculated. Two different hypotheses have been assumed for the energy spectra of the primary, viz. (*a*) that the number of particles of any energy E varies as $E^{-2 \cdot 87}$, and (*b*) that only discrete sets of isoenergetic particles, produced through the annihilation of different atoms which are found in abundance in the interstellar space, exist. The theoretical curves, when compared with the observed Agra-Peshawar difference curve, show that near the top of the atmosphere a good deal of difference in the absorption coefficient between theory and observation exists. In this region, however, the number of counts is much less than the actual ionization and the observations are also inaccurate.

A comparison of the absorption coefficient at large depths and also the sea-level latitude effect indicates definitely that the primary cosmic rays must contain protons. Whether electrons exist at all in the primary and, if so, whether hypothesis (*a*) or (*b*) approaches reality can only be determined by further observations made at closer intervals, particularly between 0° and 20° N.

Meteorology

2. The brightness of the zenith sky during twilight.

M. W. CHIPLONKAR *and* J. D. RANADE, Poona.

In continuation of previous work at Bombay and in order to eliminate the influence of the lower dusty layers of the atmosphere on the intensity of the sunlight scattered from the zenith sky during twilight, measurements of intensity were further carried out at two stations at higher levels: Poona (height above mean sea-level = 1,830 ft.) and Mt. Sinhagad (height above mean sea-level = 4,400 ft.). The intensity measurements were made with the previously described visual photometer described for different depressions of the sun below the horizon on a large number of clear moonless twilights, both before sunrise and after sunset, during the clear season of 1941-42. A green filter VG_1 (Schott and Gen.) and a red filter 27*A* (Wratten) were used. Readings could be taken with the former from about 4° 30′ to 18° and even beyond, but with the latter only from about 4° to 11° depression of the sun below the horizon. The readings were grouped separately according to time, place and the region of the spectrum. A definite influence of the lower turbid layers of the atmosphere on the brightness of the zenith sky is shown. Much smaller intensities are observed at Mt. Sinhagad and Poona than at Bombay, and in the morning than in the evening, for the same corresponding positions

of the sun below the horizon. The measurements at Mt. Sinhagad (and also at Poona where black-out conditions prevailed during the period of observations) are more reliable than those at Bombay, for (i) there are no city-lights at the former place, and (ii) the place of observation is well above the dusty layer of the atmosphere.

3. Dynamical instability of the atmosphere.

S. K. BANERJI, Delhi.

It is pointed out that the method adopted by J. Bjerknes and Patterson in deriving the criteria for the stability of the atmosphere is not free from objections, particularly because earth's rotation is not taken into account. From dynamical considerations, a more satisfactory treatment based on the circulation theorem is given. The rate of increase of circulation, dc/dt is shown to be given by

$$\frac{dc}{dt} = \oint T d\phi + W - 2\omega \frac{dF}{dt}, \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where ϕ is the entropy, W the work done by extraneous forces, and ω the angular velocity of the rotation of the earth. From equation (1), some conclusions regarding the conditions under which the dynamical and statical criteria are in conformity with each other are derived.

Electric Oscillations and Waves

4. Intensity distribution of atmospherics in different radio frequency channels.

S. R. KHASTGIR, Dacca.

A theoretical study of the intensity distribution of atmospherics in different radio frequency channels is made and the experimental results on the subject have been interpreted.

I. *Distant atmospherics.*

(*a*) Travelling as ground waves only: If the source of atmospherics gives rise to damped sinuous waves, it is shown that the field-strength of the distant atmospherics is inversely proportional to the square of frequency.

(*b*) Travelling as sky-waves only: At night the attenuation for *long waves* (100 Kc./s. or below) is practically independent of wavelength. It is shown that the field-strength of the atmospherics received on such long wave bands is inversely proportional to frequency as mentioned in Dellinger's report of data. For *medium waves*, assuming an exponential gradient for electron concentration in the ionized layer it is shown that when the frequency is of a high order, there should be an exponential decrease of field-strength with frequency. For *short waves* there is penetration through the lower E-layer and it is shown that the exponential law of decrease of field-strength with frequency is also substantially valid for short waves, as was observed in all the night experiments in the ranges: 2 Mc./s.–20 Mc./s. and 10 Mc./s.–20 Mc./s. in this laboratory.

(*c*) The general case when the atmospherics are transmitted both as ground waves and sky waves is also worked out. The results of the day-experiments are in general agreement with the deduction.

II. *Atmospherics due to local thunderstorms.*

If the disturbance consists of sharp impulses of short duration, in addition to damped sinuous waves originating at a lightning discharge, the

field-strength of the atmospherics is shown to be of the form: $E = A + \frac{B}{f}$, where A and B are constants. This is substantiated by the experiments performed here and elsewhere.

III. '*Rain-statics*'.

During continuous drizzle with slight flashes and no thunder, the field-strength of atmospherics due to electrical discharges near the receiving point should therefore vary with frequency in the same way as the field-strength of the atmospherics from the local thunderstorm centres, as confirmed by the experimental results obtained in this laboratory.

Spectroscopy

5. Study of excitation of a band system from a metal and its oxide.

N. R. TAWDE *and* A. G. HUSEIN, Bombay.

This problem arose as a result of the study of carbon arc made by Tawde and Trivedi (1939, *Phys. Soc. Proc.*, **51**, 733) by band spectroscopy methods. In the carbon arc, the AlO system $B\,^2\Sigma \rightarrow X\,^2\Sigma$ is excited first by feeding it with the substance Al_2O_3 and then with metallic aluminium. Intensity measurements made under both cases gave two different temperatures under constant arc conditions. Similar has been found to be the case with BeO system $^1\Sigma \rightarrow {}^1\Sigma$ given by beryllium oxide and metal. The results show that intensity distribution is dependent upon the chemical nature of the substances used. The radial temperature distribution within the arc has been discussed and probable dissociative processes leading to the excitation of stable molecular system have been put forth.

General Physics and Heat

6. Investigation of the composition of printing metal alloys. Part I.

S. DATTA *and* S. K. SARKAR, Rajshahi.

It is well known that the printing metal alloys generally consist of Pb, Sn and Sb with or without a trace of other metals, but the exact composition is a trade-secret. The object of these investigations was to find out the proper composition which would satisfy the physical requirements of type-metals, viz. (1) resistance to distortion, (2) hardness to withstand abrasion, and (3) some amount of fluidity in the molten state. It was believed that the above physical requirements may be satisfied by the entanglement of crystals of Sn and Sb within a homogeneous eutectic mass of Pb, Sb and Sn. A series of alloys were prepared starting from Sn 4% to Sn 10% and the percentages of Pb and Sb were adjusted so that the excess of Sn and Sb over the eutectic mass was favourable for β crystals which are formed within the temperature range 310°C. to 430°C., and which appear to be harder than other varieties of Sn and Sb crystals. The prepared alloys were subjected to various physical tests such as determination of Young's modulus, Brinell hardness, abrasion test and microphotographic analysis. As a result of these investigations it was found that the composition—Sn 5%, Sb 13·3% and Pb 81·7%—most satisfied the physical requirements.

7. Investigation of the composition of printing metal alloys. Part II.

S. DATTA *and* S. K. SARKAR, Rajshahi.

In the next series of investigations the effect of admixture of Cu in Pb, Sb and Sn alloys was studied to see how far the crystals of Cu with Sb or Sn may replace those of Sb and Sn. Investigations revealed that instead of replacing Sn-Sb crystals by Cu-Sb ones better results are achieved if Cu-Sn crystals are also allowed to be formed, as they have the property of entangling the Cu-Sb crystals, thereby preventing their segregation and ensuring an even distribution of crystals. The alloys thus prepared are hard enough for the purpose of type-metal and being of low Sn content are also cheaper but less fluid, and further investigations are needed for determining the composition which would endow the material with the required fluidity.

8. Investigation of the composition of printing metal alloys. Part III.

S. DATTA *and* S. K. SARKAR, Rajshahi.

The excess of Sn and Sb which is usually supplied in type-metals is mainly to endow the metal with sufficient strength to resist distortion and withstand abrasion. It has been found that if a thin coating of suitable metal, such as copper, be deposited electrolytically on the eutectic mass, the Brinell and abrasion hardnesses are increased. This method may have a practical application of toughening the face of the types, which are cast from ordinary eutectic mass. The excess Sn and Sb not only increases the cost of the alloy but introduces complication about the maintenance of proper temperature and mode of casting in order to obtain the best results. Now by the process of electrodeposition, the complications mentioned above could be avoided and at the same time the cost of manufacture kept low.

9. Hysteresis and time lag of Mahajan's optical hygrometer.

L. D. MAHAJAN, Patiala.

The construction, working and theory of the optical hygrometer and the comparison of its sensitiveness with other kinds of hygrometers have already been described by the author in a previous paper. In this paper the hysteresis and time lag of this instrument have been studied.

The instrument was placed in a glass chamber wherein any relative humidity could be adjusted for any period. Time taken by it to reach the maximum value was recorded. It was 15–20 min. depending upon the difference between the previous and the final humidity and also the history of the instrument.

The time lag for other kinds of hygrometers was also studied. It was observed that the paper hygrometer has 30–35 min. time lag, the hair hygrometer 20–30 min., humatograph about 50 min. and wet and dry bulb thermometers hygrometer 10–15 min. The time lag can be reduced appreciably when a slow but regular current of air is passed through it.

The hysteresis of the instrument has also been studied which shows that the instrument, when exposed to the air having the extremes of relative humidity, has 5–10% (− or +) hysteresis and requires readjustment, but otherwise there appears to be very small hysteresis which could be neglected for ordinary purposes. The instrument is very useful for the study of minor changes in humidity of the air.

10. High ceilings and summer coolness.

W. C. THOBURN, Lahore.

Common opinion and engineering practice in India both assume that high ceilings contribute to comfort and coolness in summer. A number of current and plausible theories to explain this supposed relationship have been carefully examined and tested. Scientific study supports only the explanation that, in warm weather especially, the humidity in small unventilated rooms increases rapidly. But why small rooms should not be well ventilated is not clear. The bearing on architectural practice should be significant.

11. Heat penetration through masonry.

W. C. THOBURN, Lahore.

The theory of the penetration of heat through a solid, such as a wall subjected to diurnal and annual temperature changes, is reviewed, and an experimental study of the actual thermal conditions within the mass of three masonry roofs under partially controlled conditions is described. The bearing of the results on architectural practice is stated in four points.

Apparatus, Instruments and Technical Physics

12. Direct measurements of spectral intensities.

N. R. TAWDE *and* H. A. UNVALA, Bombay.

It was the object of this investigation to set up an apparatus to read directly the spectral intensities either of bands or of lines on a relative scale. An arrangement has been evolved incorporating the Barnes-Matossi type photoelectric amplifier largely used by Bergmann, Matossi, Barnes and Matossi and Gorschinowitz and Wilson. To suit this particular work, improvements have been effected with a view (i) to eliminate aerial variations of sensitivity on the surface of photocell, and (ii) to compensate for momentary fluctuations of exciter lamp intensity. High amplification factors have been made possible.

13. Beam-splitting systems.

B. SWAMINATHAN, Chittoor.

In colour cinematography, one has to record a picture of the object in the three primary colours, so as to form three-colour negatives. The optical system used in the process has to take into account the most important errors of parallax that arise. The various systems in use are described together with their advantages and disadvantages, as also the elementary theory, underlying the construction of the various types of beam splitters.

14. On the measurement of light flashes.

D. V. GOGATE *and* Y. V. KATHAVATE, Baroda.

A photoelectric method of determining the quantity of light in light flashes and discharges of short duration is described. The method is used in estimating the amount of light emitted by burning magnesium powder, electric fuses and spark discharges.

15. A sensitive extensometer.

D. V. GOGATE *and* V. N. UPADHYAYA, Baroda.

Some years ago, Prof. Kapitza described a balance (*Proc. Roy. Soc.*, A, **131**, 1931) for the measurement of magnetization in which he made use of hydraulic magnification and damping in a very ingenious manner. In order to explore the possibilities of adopting this method for the construction of sensitive apparatus for the determination of Young's modulus, linear coefficient of expansion and such other physical constants for different metals, a series of experiments was carried out by us in this laboratory. The apparatus consists of an inverted cylindrical cup whose upper horizontal face is closed by a thin metal diaphragm. The short limb of a U-shaped narrow glass tube, open at both ends, is passed through a hole in the lower horizontal face of the cup. A cylindrical jacket covers the cup all round except the diaphragm at the top. The cup is then filled with some viscous oil (or even water) and the outer jacket is filled with water kept at a constant temperature. The apparatus is first calibrated and then used for the measurement of very small changes in length, involved in the determination of various constants.

SECTION OF CHEMISTRY

President :—S. S. Joshi, D.Sc.

General and Inorganic Chemistry

1. Magnetic susceptibility of cobaltous complexes.

Priyadaranjan Rây *and* Sailaja Prasad Ghosh, Calcutta.

Certain fairly stable cobaltous complexes of the penetration type have been prepared and their magnetic susceptibilities determined. The compounds studied are: diaquo-cobaltous *bis*acetylacetone, cobaltous ethylenebiguanidinium sulphate, cobaltous biguanidinium hydroxide and its sulphate. Of these, the preparation of the first compound was previously described by Morgan and Smith. The moment value of 2·6 Bohr found for these complexes, which is considerably lower than that of simple cobaltous ion (5·04 Bohr), furnishes definite evidence that they are of the penetration class with planar structure for the fourfold co-ordination.

2. Complex compounds of biguanide with bivalent metals. Part IV. Copper, nickel and cobalt ethylenebiguanide salts.

Priyadaranjan Rây *and* Sailaja Prasad Ghosh, Calcutta.

With a view to examine the possibility of existence of *cis-trans* isomerism in the case of planar copper and nickel complexes, ethylene biguanide—a decidedly unsymmetrical molecule—was employed as a co-ordinating addendum. Evidences for such isomerism have previously been obtained in the case of copper and nickel phenylbiguanidinium complexes by one of us. A large number of copper and nickel ethylenebiguanidinium salts, namely, chloride, bromide, iodide, sulphate, thiosulphate, thiocyanate, nitrate and nitrite, have been described. In no case indication of any possible isomerism has, however, been obtained. One of the modifications, likely the *cis*, is possibly too unstable to exist in the free state, due to steric hindrance.

Contrary to Dübsky and co-workers' (*Collection*, 1938, **10**, 112) statement a fairly stable cobaltous ethylenebiguanidinium sulphate has been prepared and its properties studied.

3. Complex compounds of biguanide with bivalent metals. Part V. Palladium biguanidine and its salts.

Priyadaranjan Rây *and* Sailaja Prasad Ghosh, Calcutta.

Palladium is known to resemble nickel in many of its chemical properties and possess like the latter an electronic structure of the pseudo-inert gas type. It was, therefore, considered worthwhile to study the preparation and properties of palladium biguanide complexes and compare them with those of nickel. Besides palladium biguanidine and its hydroxide, a number of other salts, namely, chloride, bromide, iodide, sulphate, thiosulphate, thiocyanate, nitrate, palladothiocyanate, chloropalladite and chloroplatinate have been described in this paper. The palladium biguanide complex resembles the corresponding nickel complex,

but is more stable and comparatively less soluble. The complex thiocyanate undergoes an interesting disproportionation in presence of acid to form palladium biguanidinium palladothiocyanate.

4. New compounds of indium. Part I.

P. Neogi *and* Kanai Lal Mandal, Calcutta.

A series of new compounds of the rare metal indium has been prepared. In this paper indium alizarate and calcium indium alizarate have been prepared. These indium lakes are also red in colour and can be fastened on fabrics. Other salts prepared are double sulphates of indium with sulphates of primary, secondary and tertiary amines.

5. Now compounds of gallium. Part V.

P. Neogi *and* Kanai Lal Mandal, Calcutta.

Gallium alizarate and gallium calcium alizarate have been obtained. These 'lakes' are red in colour, the gallium lake being as scarlet as the corresponding aluminium compound and the calcium gallium lake dull red in colour. These can be fastened on cotton, woollen and silk fabrics. Other salts prepared are *d*- and *l*-gallium camphor sulphates and their optical rotations have been measured. Ethylene and propylene diammonium gallium sulphates have also been prepared.

6. Reduction of oxy-acid salts of heavy metals by aluminium.

S. S. Bhate, K. K. Dole *and* D. D. Karve, Poona.

The analysis of the reaction products of various mixtures of the different sulphates and aluminium shows that, in case of low melting sulphates, there is tendency to form more free sulphur and also to form pure metallic beads. The time required for the propagation of the flame from one end of a strip of the sulphate-aluminium mixture to the other is greater in the case of high melting sulphates. The propagation is very rapid when the particle size of the sulphate and aluminium is small.

Physical Chemistry

7. Study of some consecutive reactions: hydrolysis of nitriles.

G. G. Mujumdar, K. K. Dole *and* D. D. Karve, Poona.

Hydrolysis of acetonitrile, propionitrile, normal butyronitrile, normal valeronitrile and phenylacetonitrile in presence of $2N$ sulphuric acid has been studied at various temperatures. By using freshly precipitated magnesium hydroxide, it is possible to estimate the ammonium salt alone, which is formed during the hydrolysis according to the following equation:—

$$R.CN \xrightarrow[\text{Fast}]{H_2O} R.CONH_2 \xrightarrow[\text{Slow}]{H_2O} R.COONH_4$$

After estimating the ammonium salt, the amide is estimated by reacting it with sodium hydroxide. Thus the two stages are estimated separately. The propionitrile hydrolyzes faster than any of the nitriles studied in the investigation (even faster than acetonitrile). The temperature coefficient varies with the change in the temperature, indicating the composite nature of the reaction. The values of velocity constant k_1 for the diminution of nitrile are found to be fairly constant, in the earlier stages of the reaction. The value of velocity constant K of nitrile into ammonium salt reaction depends upon the slower of the two reactions.

8. Catalytic decomposition of bleaching liquor in the presence of salts of nickel, cobalt and copper.

G. B. KOLHATKAR *and* U. A. SANT, Poona.

Kinetics of the decomposition of sodium hypochlorite in bleaching liquor in the presence of peroxides of nickel and cobalt and in the presence of oxide of copper is studied. The reaction occurring in the decomposition is a unimolecular one. The catalytic activity of peroxides of nickel and cobalt and oxide of copper is in the ratio of 100 : 49 : 6·9. The concentration of the alkali present in the bleaching liquor has a marked influence on the velocity of the decomposition. The velocity constants decrease as the concentration of the alkali is increased. The velocity of decomposition also depends on the concentration of the catalyst. The velocity constant falls as the concentration of the catalyst is diminished, but the fall in the constants is less rapid than that in the concentration of the catalyst.

9. Kinetics of reactions in heterogeneous systems.

P. S. JAVADEKAR, K. K. DOLE *and* D. D. KARVE, Poona.

Hydrolysis of benzoyl chloride, phthalyl chloride and benzoyl bromide in liquid-liquid systems has been studied with special reference to the temperature coefficients. Temperature coefficients increase with temperature in case of benzoyl and phthalyl chlorides but decrease in case of benzoyl bromide. Change in speed of stirring has no effect on benzoyl chloride reaction. But a marked effect is observed in case of phthalyl chloride and benzoyl bromide reactions. Also in presence of potassium sulphate, benzoyl chloride shows increase in values of k with increased speed of stirring. Addition of potassium sulphate and diphenyl diminishes the velocity of the reactions. The temperature coefficients are increased in presence of a neutral electrolyte.

Further work on the reaction between β-naphthoic acid and sodium hydroxide is being carried out and the results will be published in due course.

10. Velocity of hydrolysis of anilides.

B. W. KELKAR, K. K. DOLE *and* D. D. KARVE, Poona.

The velocity of hydrolysis by sulphuric acid of different strengths of the compounds formanilide, form-*o*-toluidide, form-*p*-toluidide has been studied. 50% alcohol was used as solvent and the extent of hydrolysis was determined by titrating the acid liberated by means of standard alkali. Further work with other anilides and also using other solvents is in progress.

11. Effect of temperature on the interaction of hydrogen clays with neutral salts.*

J. N. MUKHERJEE, B. CHATTERJEE *and* P. C. GOSWAMI, Calcutta.

Estimations have been made at 0°C., 28°C. and 75°C. of the amounts of (i) aluminium displaced, (ii) acid liberated, and (iii) barium adsorbed on the addition of 0·2N $BaCl_2$ to two hydrogen clays prepared from an acid soil from Assam and a non-lateritic calcareous soil from Padegaon. In the experiments with the hydrogen clay from the Assam soil temperature has no marked effect on (i), (ii), and (iii). With the other hydrogen clay, (i) remains practically constant (26·0 milli-equivalents per 100 g. clay)

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* The work has been carried out under a scheme of 'Research into the Properties of Colloid Soil Constituents' financed by the Imperial Council of Agricultural Research, India.

for 0°C. and 28°C. but shows an appreciable fall to 19·0 m.e. at 75°C.; (ii) and (iii) have respectively almost constant values of about 52·7 and 45·5 m.e. per 100 g. for 28°C. and 75°C. but decrease to 47·8 and 36·0 m.e. per 100 g. at 0°C.

12. The rôle of the specific surface in determining the base exchange capacity of subfractions of hydrogen clays and hydrogen bentonites.*

J. N. MUKHERJEE, R. P. MITRA *and* K. C. GHOSH, Calcutta.

The specific surface of four hydrogen clays and five hydrogen bentonites prepared from subfractions separated from the entire clay fraction of a black cotton soil from Padegaon and a bentonite from Hati-ki-Dhani has been obtained in three ways—S_1, from the average particle size; S_2, from the amount of methylene blue adsorbed per gramme; and S_3, from the base exchange capacity (b.e.c.) per gramme, assuming that the exchangeable cations are held against a monoionic layer of OH^- ions on the surface. All three values tend to increase with diminishing particle size. For the same subfraction, they usually decrease in the order $S_2 > S_1 \gtrless S_3$. The b.e.c. (T) per square metre calculated by using the value S_1, i.e., T/S_1, decreases with diminishing particle size indicating that the particles have considerable inner surfaces and/or fresh layers are exposed as the reaction with the base proceeds. S_1 does not include the inner surfaces, S_2 and S_3 do. The b.e.c. per square metre calculated from S_2, i.e. T/S_2, remains fairly constant. T/S_3 is necessarily constant as S_3 has been calculated from T.

13. The simultaneous action of light of different frequencies on photochemical reactions, as an additional and important characteristic for establishing the mechanism of photochemical reactions.

T. BANERJEE, Dacca.

Attempts to establish the mechanism of photochemical reactions with the help of the usual characteristics, e.g. quantum efficiency, influence of absorbed radiations and reactants on the velocities of reactions, temperature coefficient, etc., have, in many cases, led to controversies. The author has shown in this paper how the study of an *additional* characteristic, viz. the simultaneous action of light of different frequencies (where possible) on photochemical reactions, can throw considerable light on the problem by suggesting a plausible mechanism of the newly studied photochemical reactions and further confirming the previously existing mechanism. The reactions he selected for investigation are: (1) the oxidation of organic acids by ferric chloride in $366\mu\mu$ and $436\mu\mu$, (2) photo-bromination of cinnamic acid and stilbene in $405\mu\mu$, $436\mu\mu$ and $546\mu\mu$, and (3) photochemical decomposition of complex formed between chloroplatinic acid and potassium bioxalate or potassium malonate in $366\mu\mu$ and $436\mu\mu$.

14. Photochemical after-effect in the bromine-citric acid reaction.

P. S. MACMAHON *and* T. N. SRIVASTAVA, Lucknow.

The reaction between Br_2 and citric acid takes place entirely in the dark with a measurable velocity. The value of the unimolecular

* This work has been carried out under a scheme of research financed by the Imperial Council of Agricultural Research, India.

velocity constant '*k*' decreases with time, which is due to the production of increasing quantities of HBr. If initially excess of HBr is added, the reaction becomes very slow and '*k*' becomes practically constant. On addition of HBr, the value of '*k*' decreases as the concentration of HBr is increased, until a limit is reached when the reaction is totally suppressed, after which further addition of HBr produces no effect. The reaction has a positive temperature coefficient.

The reaction has a photochemical after-effect but owing to the fall of the velocity constant in the dark, the after-effect is very much masked. With $N/10$ citric acid and $N/100$ Br_2, the observed unimolecular velocity constant, after the solutions have been exposed to sunlight, is almost twice that in the dark. If, however, by adding HBr the dark rate is slowed down and made practically constant, the after-effect becomes very pronounced. By using suitable concentrations of HBr an increase in the velocity constant as much as about 30 times has been observed.

The photochemical after-effect increases with the time of illumination and decreases with increase of temperature and also with increase in concentration of HBr. The decay of the after-effect is slower at lower temperatures than at higher. If fresh Br_2 is added to the end solution when the after-effect has reverted to the normal dark rate, no secondary after-effect is observed as in the I_2-oxalate reaction.

Further work is necessary for suggesting a satisfactory explanation for the after-effect and is in progress.

15. Effect of hydrogen-ion concentration on the wall-building properties of oil-well-drilling muds.

A. Reid *and* N. C. Sen Gupta, Calcutta.

Water from drilling mud diffuses into the formation and the residue forms a sheath on the walls of the bore hole; this phenomenon is termed wall-building. A good drilling mud should lose very small amount of water and form a very thin sheath. This water-loss from a mud is strongly influenced by the *p*H of mud. It has been observed that the amounts of water filtered in a given time from a mud at constant pressures vary in the same way as the buffer capacities on addition of acids and alkalis. Both the buffer capacity and the water-loss for a particular drilling mud were found to pass through a minimum round about *p*H 9.

16. Acetone-salt-water system.

N. C. Sen Gupta *and* A. Hamid, Calcutta.

Phase rule studies of the three component system acetone, salt and water were made in order to ascertain the possibilities of separating acetone from acetone-water mixtures. A triangular diagram is presented showing the limits of concentrations within which the three components form a single liquid phase and the equilibrium between two saturated solutions water in acetone and acetone in water and solid salt. Compositions having minimum solubilities for acetone are represented by a line in the diagram.

17. Experiments with some Indian bentonites.

N. C. Sen Gupta *and* M. M. Dey, Calcutta.

Physico-chemical properties of four samples of Indian bentonites and their relative suitabilities in making drilling muds for oil-wells were studied. A sample of white bentonite from Kashmir has the highest base exchange capacity; but it contains a high percentage of exchangeable calcium ions. This bentonite unless properly treated with chemicals shows low swelling and poor wall-building properties. Of the other three,

Akli bentonite has a high base exchange capacity and a high percentage of exchangeable sodium ions. It also shows a high swelling and excellent mud-making properties. Another sample of bentonite supplied by an Indian firm also has properties comparable to those of Akli bentonite. Potentiometric titrations with acids and alkalis show that both in the acid and the alkaline region Kashmir bentonite has a stronger buffer action than the rest. Sediment volumes of bentonites vary with pH generally passing through a maximum between pH 9·0 and 9·5. When treated with sodium carbonate the bentonite samples show thixotropy at moderate concentrations.

18. Some studies on bituminous emulsions.

N. C. Sen Gupta, Calcutta.

Attempts were made to emulsify bitumen in water using various reagents of which a mixture containing casein, tannic acid and caustic soda in proper proportions was found to be most suitable. The emulsion of bitumen thus obtained could be diluted with water without any appreciable reduction in stability. Viscometric measurements showed that the emulsions possessed yield values until diluted below 7% bitumen by weight of emulsion. Potentiometric titrations of a 5% emulsion using acids and alkalis revealed a dibasic acid character of the emulsion with inflexion points at pH 5·9 and 8·6 respectively and a strong buffering round about pH 7·5. The emulsion could be coagulated by raising the pH above 10·5 or lowering it below 7. Calcium chloride appeared to be a better coagulating agent than sodium chloride at corresponding concentrations.

19. Supersaturation limits of solutions.

A. C. Chatterji *and* Ram Gopal, Lucknow.

In a previous paper (*Proc. Ind. Sci. Cong.*, 1942) it was shown experimentally that the heat of solution (molecular) of a number of potassium salts is inversely proportional to the corresponding supersaturation limit $T_s - T$, i.e.

$$\lambda(T_s - T) = K \text{ (a constant)},$$

where λ denotes the molecular heat of solution of the salt concerned. The value of the constant K has been found to be approximately equal to 84,500. As usual, T_s denotes the temperature of saturation and T the temperature at which spontaneous crystallization occurs when the solution is cooled uniformly in a sealed tube.

A theoretical deduction of the above relationship based on the theory of supersaturation of Jones and Partington (*Phil. Mag.*, 1915, 29, 35) is given.

20. Studies in glass systems—X-ray analysis of NaCl dissolved in B_2O_3-glass.

Subodh Kumar Majumdar, Calcutta.

Majumdar and Sarma (*J. Ind. Chem. Soc.*, 1942, **19**, 241) have recently studied the change in the mole-refraction of polar crystals when dissolved in B_2O_3-glass. Majumdar and Wulff (*Z. physikal. Chem.*, 1936, **B**, **31**, 319) had earlier investigated the system x Na_2O, y B_2O_3 and found that $Na_2B_4O_7$ is deformed much more strongly in solid solution of B_2O_3 than in the corresponding aqueous solution. The present paper gives the results of X-ray analysis of NaCl dissolved in B_2O_3-glass. The samples were prepared by dissolving pure sodium chloride in pure and anhydrous boric oxide at high temperature and allowing the melt to solidify. The solid

was then powdered and the Debye-Scherer photograph taken in the usual way. Photographs were also taken of pure NaCl, pure $Na_2B_4O_7$, $10H_2O$ crystals (without melting) and different samples of B_2O_3-glass containing varying amounts of sodium chloride. The lines corresponding to the borate were eliminated by comparison and it was found that NaCl still retained its cubical crystalline structure when dissolved in boric oxide glass but the spacing was 9·008Å, which represents an increase of more than 66% over the value in the pure crystal. A theoretical explanation is sought to be given as due to the altered dielectric.

21. Studies in glass-systems—magnetic susceptibilities of sodium chloride dissolved in borax glass.

SUBODH KUMAR MAJUMDAR, Calcutta.

Samples of solid solutions of sodium chloride in borax glass were prepared in the same way as detailed in the previous paper. The magnetic susceptibility of the samples was determined by the Guoy method. Experiments were also made with the pure samples. From the value of the glass experimentally determined, the magnetic susceptibility of the dissolved NaCl was calculated on the assumption that the value for borax remained constant in the mixture. The magnetic susceptibility of NaCl dissolved in the glass showed an increase of the negative value. This is explained as due to the deformation of the crystals in the glass systems. The results are consistent with similar observations on the change of mole-refractions noticed in other solid solutions by the present author. Further experiments are in progress in this line.

22. On the nature of the gels of silicic acid and aluminium hydroxide and some synthetic and natural alumino-silicates.

S. P. RAYCHAUDHURI, Dacca.

(i) It is found that mixing of oppositely charged colloidal solutions of silicic acid and aluminium hydroxide, even in widely differing SiO_2/Al_2O_3 ratios, always results in precipitation. Below a ratio of SiO_2/Al_2O_3 equal to unity of the precipitated mass, the precipitate gets sticky.

(ii) At lower SiO_2/Al_2O_3 ratios, the precipitate contains free alumina and is positively charged while at higher SiO_2/Al_2O_3 ratios, it contains free silica and is negatively charged. As the SiO_2/Al_2O_3 ratio increases, from low to high values, the electrical charge passes through a minimum and then gets increasingly negative.

(iii) Electro-osmotic measurements show that for the negatively charged gels of synthetic alumino-silicates, considerable amount of cation exchange is possible. The cation exchange capacity increases with the silica content of the precipitate showing a maximum when the alumino-silicate consists of 80–90% of silica. Pure silicic acid gel shows little exchange capacity. The order of cation exchange in case of negatively charged precipitates is found to be

$$Li^+ < Na^+ < K^+ < Mg^{++} < Ca^{++} < Ba^{++} < Al^{+++}$$

namely that of the Hoffmeister series. With positively charged gels, the cation exchange is less, though the order is the same as above. Cataphoretic data with kaolin, which is negatively charged, also point to the same order of exchange.

(iv) Electro-osmotic data with the negatively charged gels and cataphoretic data with kaolin show that compared to cation exchange the anion exchange is much less; the order is found to be

$$Fe(CN)_6''' > HPO_4'' > I' > SO_4'' > Br' > Cl' > NO_3'$$

(v) It is observed that the buffer curves of the naturally occurring alumino-silicates, namely bauxite, kaolin, halloysite, limonite and montmorillonite, show but little similarity with the buffer curves of the precipitated gels, the latter having much higher buffer capacities. This may be due to the existence in synthetic gels, of capillary structure, which should be destroyed by aging and weathering before comparisons with the naturally occurring gels can be made.

23. Charge and stability of colloids. Part VIII. Study of ionic antagonism by potentiometric titration of the uranium ferrocyanide sol.

B. P. YADAVA *and* A. C. CHATTERJI, Lucknow.

It was reported in previous communications of this series (*Indian Sci. Cong.*, 1942) that manganese dioxide sol on being titrated potentiometrically with mixtures of KCl and $BaCl_2$ shows a marked ionic antagonism. The present investigation reveals that uranium ferrocyanide sol also under similar conditions exhibits a similar ionic antagonism.

As a result of the study of the adsorption of the similarly charged ion by the colloid, it is observed that when the sol of uranium ferrocyanide is titrated singly by KCl or by $BaCl_2$, the percentage adsorption of the similarly charged ion, viz. chlorine ion, is very low, whereas when the same sol was titrated by taking these electrolytes in pairs the percentage adsorption of the similarly charged ion considerably increased. It is believed, therefore, that the 'ionic antagonism' observed also in this case is due to the greater adsorption of the similarly charged ion, when one electrolyte is added in presence of the other.

24. Permeability of sodium-hydrogen soil.

K. P. SHUKLA, Lucknow.

When a pure sodium soil is treated with a dilute mineral acid a soil containing exchangeable hydrogen and sodium is produced. The replacement of exchangeable sodium takes place according to the equation:

$$Z].Na + HCl \rightleftharpoons Z].H + NaCl.$$

The permeability of sodium soil is found to increase with the proportion of exchangeable hydrogen in the complex and a relation of the following type holds good:

$$y = Ke^{n(H^+/B)},$$

where y = rate of percolation; H = quantity of exchangeable hydrogen; B = base exchange capacity; K and n are constants.

The constant K is a function of the properties of *saturated* sodium soil.

25. Exchangeable cations and the permeability of soil.

K. P. SHUKLA, Lucknow.

In a previous paper (*Proc. Indian Sci. Cong.*, 1942, p. 73), the effect of increasing quantities of exchangeable Na on the permeability was discussed. Here an attempt has been made to compare the effect of three alkali cations (Na, K, NH_4) on the permeability of a calcium soil.

Increasing quantities of carbonates of Na, NH_4 and K brought about an increasing reduction in the rate of percolation of water in pure Ca-soil. The effect in each case reached a maximum value when 6 to 7% of the chemical was added. The efficiency of the three salts in reducing percolation was in the order:—$Na_2CO_3 > (NH_4)_2CO_3 > K_2CO_3$. Capacities of these salts for replacing exchangeable Ca from the soil were found to be

in the reverse order, i.e. $K_2CO_3 > (NH_4)_2CO_3 > Na_2CO_3$. Percolation experiments were also repeated with pure, Ca-alkalisoil, in which Ca^{++} was progressively replaced by Na^+, NH_4^+ and K^+ ions respectively. It was found that, in general, the rate of percolation y was related to the saturation coefficient S by the relation:—

$$y = ae^{-bs}$$

where S is the quantity of exchangeable alkali cation expressed as percentage of base exchange capacity, y the rate of percolation in cm. per hour, and a and b constants. The values of these constants were as follows:—

	K	NH_4	Na
a ..	0·1800	0·1720	0·1400
b ..	0·0067	0·0227	0·0440

The constants follow the same order as that of hydration of ions. Dispersion coefficients, namely, the percentage of clay in suspension when Ca is progressively replaced by Na, NH_4 and K also follow the order of hydration of ions.

Thus, when the permeability, ease of exchange of Ca and coagulating power of the three ions are compared, they are in the order of decreasing hydration, viz. $K^+ > NH_4^+ > Na^+$.

26. Dependence of the electrical charge of a precipitate on conditions of precipitation and presence of electrolytes.

S. G. CHAUDHURY *and* K. BHATTACHARYA, Calcutta.

It has been shown in this paper that the charge of the copper ferrocyanide precipitate sometimes becomes negative and sometimes positive when copper sulphate and potassium ferrocyanide solutions are simultaneously or alternately added to water drop by drop such that the final concentrations of the precipitants are 0·005*N*. The cataphoretic velocity of the ferrocyanide precipitate appears to depend on the concentration of the precipitants. If the precipitates are washed by centrifugalization into a sol by peptization, the larger particles of a pure sol have a higher velocity than the smaller particles. In presence of $BaCl_2$ the sol shows at first a diminution and afterwards an increase in the cataphoretic velocity such that the cataphoretic velocity of the sol in presence of $BaCl_2$ is higher than that of the pure sol after 2½ hours.

27. Electrochemical properties of synthetic mixtures of colloidal silicic acid and aluminium and ferric hydroxides.*

B. CHATTERJEE *and* A. SEN, Calcutta.

Two synthetic systems have been prepared by mixing different amounts of colloidal silicic acid and aluminium and ferric hydroxides. Their *p*H and specific conductivity change with time indicating a slow reaction between the ingredients. The potentiometric titration curves with sodium hydroxide show an inflexion point between *p*H 7·0 and 8·0 as observed with several hydrogen clays previously studied in this laboratory. The titration curves of the pure ingredients, i.e. the sols of silicic acid and aluminium and ferric hydroxides do not show an inflexion point in this region. Aluminium is liberated on the addition of barium

* The work has been carried out under a scheme of 'Research into the Properties of Colloid Soil Constituents' financed by the Imperial Council of Agricultural Research, India. Prof. J. N. Mukherjee is the director of the scheme.

chloride to the mixtures. Its amount is, however, much smaller than that found for hydrogen clays having practically the same mass chemical composition as the synthetic mixtures. Oxalic acid dissolves sesquioxides from the latter, the amount increasing with the concentration of the acid. Practically all the iron in one of the mixtures dissolves at a concentration of 0·09*N* of the acid.

28. A new theory of electric moment.

S. K. K. JATKAR, Bangalore.

The calculation of bond moments of molecules for gases, liquids and solids by the new law has revealed the fact that the dipole action is due to partially ionic character which is governed by the screening electrons and can be calculated by resonance structures. The calculation of the dipole moment of molecules in solid state by the susceptibility law is similar to that used in calculating magnetic moments. The author claims that the so-called dipole rotation in solids is a myth and that we have here the evidence for the long sought electric analogue of the magnetic moment, the dipole moment being due to the motion of the electron between the two nuclei, the distance covered being governed by the interaction of electrons between the two atoms and the components of other bond moments in the molecule.

29. Fission on aromatic ethers by halogen acids in different solvent.

S. P. WALVEKAR, N. L. PHALNIKAR *and* B. V. BHIDE, Poona.

Mechanism of the fission of an aromatic ether is represented by the following scheme:—

$$\mathrm{PhOR + HX \rightleftarrows Complex \rightarrow PhOH + RX}$$

where R = alkyl radical and X = a halogen.

Previous experiments on the vapour pressures of halogen acids in presence of ethers in carbon tetrachloride and hexane solution failed to give any definite evidence for the formation of a critical complex. Fission of ethers by hydrogen chloride and hydrogen bromide was studied at 70° in various solvents in presence and absence of bases like pyridine, dimethyl aniline, aniline, etc. It was found that in absence of bases there was no fission at all in carbon tetrachloride and hexane solutions but in presence of a base fission was considerable. When polar solvents like nitrobenzene, chlorobenzene and acetic acid, etc., were used, it was found that the fission was greatest in the solvent with the highest dielectric constant. The extent of fission was increased by the presence of bases. These experiments lead to the following conclusions:—

(i) The halogen acid has a covalent linkage in carbon tetrachloride and hexane. In this form the critical complex is not formed.

(ii) If a base is present the covalent linkage changes to an electrovalent linkage due to salt formation and then the critical complex is easily formed.

(iii) A solvent of a high dielectric constant leads to a partial or complete change of the covalent linkage into the electrovalent linkage in the halogen acid and hence again the formation of a critical complex is favoured as shown by the extent of fission of the ether.

A mechanism of the reaction is proposed in the light of the above observations.

Organic Chemistry

30. Condensation of aromatic aldehydes with malonyl-toluidic acids, in presence as well as absence of traces of pyridine.

P. I. Ittyerah *and* K. C. Pandya, Agra.

The effeciency of a trace of pyridine in catalyzing condensations of aromatic aldehydes with malonic acid appears to be influenced by various circumstances and groups. A study of different groups present on the ring of the aromatic aldehydes has already been presented. The fact that various groups on the malonic acid molecules also exert powerful effects was brought home by the extreme slowness of these condensations when malonic acid is replaced by diethyl malonate and the appreciable success when it is replaced by malonanilic acid. In the present work, instead of malonanilic acid malon-*o*-toluidic, malon-*m*-toluidic and malon-*p*-toluidic acids are condensed with a large number of aromatic aldehydes. The reactions went still better, the yields being on the whole much greater than in the case of malonanilic acid even.

As was noticed earlier, the trace of pyridine promoted the condensation as well as decarboxylation, resulting in the formation, wholly or mainly, of the corresponding cinnamylidine. In its absence the corresponding benzylidene-malon-toluidic acid was formed. The influence of the hydroxy-, methoxy-, methyl groups on the reaction and on the yields is also very noticeable and is very much in line with previous observations.

Over forty new compounds have already been obtained and the work is in progress.

31. Condensation of malonic acid with 5-bromosalicylaldehyde and 3 : 5-dibromosalicylaldehyde, with and without pyridine.

Kantilal C. Pandya, Agra.

The influence of the halogen group, namely the chlorine and the bromine, in increasing, both the yield and the speed of the reaction, when present on the aromatic ring of the aldehyde, has already been noted by Pandya and Miss Pandya. As the hydroxy-group in the ortho position to the aldehyde always decreases both the yield and the velocity of the reaction, now understandable as the ortho-effect due to the hydrogen bond, it seemed interesting to see whether any increase or modification would occur in the speed and the yield when a promoting group like bromine was also present on the ring. Thus condensations with 5-bromosalicylaldehyde and 3 : 5-dibromosalicylaldehyde with malonic acid have been studied.

The experimental work was started by Mr. Mahendraray Kikani and the main work was done and completed by Miss Rashmi Bala Pandya. The results are very interesting. In the presence of pyridine, the reaction appears to have been quickened but the final yields are not much increased. In the absence of pyridine, however, with longer time of heating, the yields are considerably higher. Several new compounds have been obtained. The work is to be extended with chloro-derivatives of salicylaldehyde as well as with the haloid derivatives of *m*- and *p*-hydroxybenzaldehydes.

32. Preparation of sulphathiazoles.

U. P. Basu, Baranagar (Calcutta).

By condensing a 2-halogeno derivative of a thiazole with *p*-amino benzene sulphonamide in presence of copper bronze powder and anhydrous alkaline carbonate at a higher temperature (175–190°C.), 2-(*p*-amino

benzene-sulphonamido)-thiazoles may be easily prepared. Thus 2-(*p*-amino benzene-sulphonamido)-thiazole, m.p. 202° and, 2-(*p*-amino-benzene-sulphonamido)-4-methyl thiazole m.p. 236-237° (*cf.* Das Gupta and Basu, *J. Indian Chem. Soc.*, 1941, **18**, 168) were isolated in good yields.

33. Inhibitive influence of an acetyl group in position 3 in a chromone on condensation with benzaldehyde.

G. R. KELKAR, Poona.

Influence of an acetyl group in the position 3 in a chromone on Fries migration has already been observed (Kelkar and Limaye, *Rasayanam*, 1936, I, 60; 183).

Now 5-methoxy-2-methyl-chromone $C_{11}H_{10}O_3$, m.p. 107°, obtained by deacetylation of 5-methoxy-2-methyl-3-acetyl-chromone (Limaye and Kelkar, *Rasayanam*, 1936, I, 29) has been found to condense with two molecules of benzaldehyde to form α-γ-di-(5-methoxy-chromone-2)-β-phenyl propane, $C_{29}H_{24}O_6$, m.p. 173°, while 5-methoxy-2-methyl-3-acetyl-chromone is not amenable to condensation under similar conditions (cf. *ibid.*, p. 26).

34. Synthetical anthelmintics. Synthesis of γ-alkyl β-*p*-methoxy (hydroxy) phenyl butyrolactone.

(MISS) K. PARANJAPE, N. L. PHALNIKAR *and* K. S. NARGUND, Poona.

Reformatsky's reaction of ethyl bromacetate with *p*-methoxy-phenyl alkyl ketone gave the ethyl β-*p*-methoxy phenyl-γ-alkyl-β-hydroxy butyrate (I). The dehydration of (I) with P_2O_5 in benzene solution, followed by hyrolysis in cold gave the unsaturated acid (II) which on treatment with sulphuric acid yielded γ-alkyl-β-*p*-methoxy phenyl butyrolactone (III). Demethylation of (III) gave the corresponding hydroxy-butyrolactone (IV). Lactones containing alkyl groups like ethyl, propyl, butyl, valeryl, hexyl, tetradecyl and hexadecyl have been prepared.

35. Synthetical anthelmintics. Synthesis of lactones similar to desmotropo-santonin.

(MISS) K. PARANJAPE, N. L. PHALNIKAR *and* K. S. NARGUND, Poona.

Rosenmind and Schapiro (*Arch. Pharm.*, 1934, 272, 313) have shown that γ-butyrolactones having a methoxy (hydroxy) phenyl group have marked anthelmintic properties. Caius Mhaskar (*Ind. Jour. Med. Res.*, 1923, **11**, 371) investigated the anthelmintic properties of desmotropo-santonin and concluded that it was not a good anthelmintic. This conclusion is based on the study of only one substance. It was, therefore, considered desirable to study the anthelmintic properties of compounds related to desmotropo-santonin. The lactones prepared in this connection are described in this paper.

Reformatsky's reaction of ethyl bromacetate with 7-methoxy 1-tetralone gives ethyl 1-hydroxy, 7-methoxy, 1, 2, 3, 4-tetrahydro naphthyl acetate (I). The dehydration of (I) with P_2O_5 in benzene solution, followed by hydrolysis gives the unsaturated acid (II) which gives the lactone (III) on treatment with H_2SO_4. Demethylation of (III) gives the corresponding hydroxylactone. Similar reactions have been carried out with 1-keto, 5-methoxy, 8 methyl, 1, 2, 3, 4-tetrahydronaphthalene and the corresponding lactones have been obtained.

It may be noted that the lactones described in the present work are similar to desmotropo-santonin but differ from the latter in having no methyl group in the lactone ring and the position of the lactone ring is exactly the reverse.

36. Long chain acyl and alkyl phenols.

(MISS) K. PARANJAPE, N. L. PHALNIKAR *and* K. S. NARGUND, Poona.

The long chain acyl and alkyl phenols were required in this laboratory in connection with the work on synthetical anthelmintics. Recently Bell and Driver (*J. Chem. Soc.*, 1940, 836) have prepared heptadecyl and dodecyl phenols by Fries' migration of the corresponding esters. The Fries' migration always gives a mixture of ortho- and para-compounds. Bauer and Ralston (*J. Org. Chem.*, 1940, **5**, 165) have obtained mixtures of ortho- and para-heptyl, undecyl, tridecyl, pentadecyl and heptadecyl phenols by the Friedel and Craft's reaction of the acid chloride and phenol. The present paper describes the preparation and properties of acyl and alkyl phenols from stearic, palmitic, myristic and lauric acids. It has been found that the Nenckie's reaction with the acid and the phenol gives always the ortho-compound, the para- if formed, never more than 1%. Friedel and Craft's reaction of the acid chloride and anisole, however, gives only the para-acyl-methoxybenzene as the sole product (yield 90%). The orientation of these ketones as ortho- and para-compounds has been determined by the oxidation of their methyl ethers. The Clemmemson reduction of these ketones gives the corresponding alkyl phenols.

37. Synthesis of *n*-pilosinine.

A. N. DEY *and* J. D. TIWARI, Ghazipur and Allahabad.

Attempts to prepare *n*-pilosinine by condensing 4- (or 5-) (γ-phenoxy-β-chlor) propyl glyoxaline and sodiomalonic ester were unsuccessful. This was, however, realized by another method which also has the advantage of being applicable as a general method of synthesis of alkaloids of this group and would enable to determine the position of the methyl group in these compounds more precisely. This method is based on the preparation of the corresponding amino-aldehydo-lactone from homopilopic by reacting the acid chloride of the latter with hydrocyanic acid, and converting the ketonitrile thus obtained into the corresponding keto-acid. The oximino derivative of this keto acid on reduction with Pd-charcoal was reduced to the corresponding amino acid. The amino acid was converted into the phthalimino derivative whose acid chloride on reduction with Pd-$BaSO_4$ gave the corresponding aldehyde. The amino aldehyde thus obtained reacts with ammonium thiocyanate to give thiol-norpilosinine, which on oxidation with ferric sulphate gave pilosinine identical with the compound obtained by Polykova, Preobrashenkii and Preobrashenskii (*J. Gen. Soc.*, 1939, U.S.S.R., 9, 1402).

38. The component glycerides of vegetable fatty oils. Part II. Safflower oil.

N. L. VIDYARTHI, Patna.

The safflower seeds (*Carthamus tinctorius*) yield 30·5% of oil which contains myristic acid (along with lauric and other lower acids) 1·5%, palmitic acid 3%, stearic acid 1%, archidic acid with a trace of lignoceric acid 0·5%, oleic acid 33%, linolic acid with a trace of linolenic acid.

The glycerides have been determined by the bromination of the neutral oil and the component glycerides have been found to be myristo-

oleo-linolin 2%, myristodilinolin 1%, palmit-oleolinolin 7%, palmitodilinolin 4%, stearo-oleo-linolin 2%, stearodilinolin 1%, deoleo linolin 15%, oleodilinolin 63% and tri-linolin 3%. The myristoglycerides contain a little of lauric and other lower acids, stearoglycerides contain little of archidic and lignoceric acid and the tri-linolin contains traces of linolenic acid.

39. Chemical examination of the seeds of *Amaranthus gangeticus*, Part I. The fatty oil of the seeds.

N. CHIDAMBARAM *and* R. RAMACHANDRA IYER, Trivandrum.

The fatty oil from the seeds of *Amaranthus gangeticus*, a variety of Amaranthus, indigenous to South Travancore has been examined. It has been found to contain mainly palmitic acid 20·84%, stearic acid 2·16%, oleic acid 43·7% and linoleic acid 27·3%, all on the basis of the oil and 2·6% unsaponifiable matter.

40. Isolation of populneol, a new phenolic compound from the flowers of *Thespasia populnea.*

P. SURYAPRAKASA RAO, Guntur.

A new colourless phenolic compound named populneol has been isolated from the flower-petals of *Thespasia populnea*. It melts at 116–18° and has the formula $C_{15}H_{12}O_3$. It easily dissolves in dilute sodium hydroxide, and gives a dull violet colour with ferric chloride.

41. Chemical examination of the bark of *Prunus paddam.*

D. CHAKRAVARTI, Calcutta.

The bark of *Prunus Paddam* (N.O. Rosacea), collected from Darjeeling, has been found to contain the following substances:—

(i) A substance, m.p. 150-51°. Colourless fine needles, yield 2%. The provisional formula $C_{13}H_{12}O_4$ has been assigned to it from its analytical data and molecular weight determinations. It contains one methoxy group. It forms a methyl ether (m.p. 120°), a benzoyl derivative (m.p. 72-73°) and an acetyl derivative (m.p. 120°).

(ii) A deep yellow substance, m.p. 282°, yield 0·02%.

(iii) A light yellow substance, m.p. 224°, yield 0·5%.

The substances are under investigation.

42. Chemical examination of the bark of *Prunus nepalensis.*

D. CHAKRAVARTI *and* S. A. MOMEN, Calcutta.

Two crystalline products have been isolated from the bark of *Prunus nepalensis* (N.O. Rosacea): (1) m.p. 248-49°, yield 0·08%, fine needles. $C_{33}H_{56}O$. (2) m.p. 275-76°, yield 0·02%, hexagons, $C_{31}H_{54}O$. The substances are under investigation.

43. Essential oil from *Adenosma capitata.*

P. V. NAIR, K. S. MADHAVAN PILLAI *and* N. S. VARIER, Trivandrum.

***Adenosma capitata* (Mal. Karpoora Chedi; Natural Order: Scrophularinae) grows wild in great profusion in North and Central Travancore and usually blooms during the post-monsoon periods. The leaves and flowerheads, which give a characteristic camphor-like aroma when**

rubbed, were distilled in steam and the essential oil collected therefrom has been found to contain over 60% of *l*-limonene, 5-6% of alcohols and the rest of sesquiterpenes. The total yield of oil was roughly 1·0% on the weight of the air-dried raw material. The following physical and analytical constants for the oil were obtained: $d^{30}_{30} = 0{\cdot}903$, $n^{30}_{D} = 1{\cdot}4704$, $(a)^{30}_{D} = 39{\cdot}4$, acid value = 0·5, ester value = 6·5, acetyl value = 20·2, alcohols as $C_{10}H_{18}O$ = 5·5, absorption with 5% NaOH = *nil*, absorption with $NaHSO_3$ = *nil*, solubility in 70% alcohol = *nil*, solubility in 80% alcohol = 1 in 13, solubility in 90% alcohol—miscible in all proportions.

The oil was distilled under diminished pressure and the fractions collected up to 110°C. were bulked together and distilled over sodium. The physical constants of the final distillate bore a striking proximity to the corresponding constants for *l*-limonene and definite proof of their identity was sought in the bromo-compound of the distillate, which was found to be identical with *l*-limonene-tetrabromide. The higher boiling fractions from the reduced pressure distillation have been found to be dextrogyrate and presumably consist of sesquiterpenes.

Biochemistry

44. Studies on Travancore *tapioca*. Part I. Analysis of the different varieties.

N. S. Varier *and* A. V. Mathew, Trivandrum.

Different varieties of *tapioca* grown in Travancore have been analytically studied with a view to compare their nutritional values. A method of supplementing a *tapioca* diet is discussed.

45. Studies on haemolysin (lecithinase) isolated from cobra (*Naja Tripudians*) venom. Part I. Crystalline haemolysin.

S. S. De, Calcutta.

Snake venom contains various toxic components like neurotoxin, haemolysin, coagulant and haemorrhagin, etc. Hitherto only the neurotoxin fraction of cobra venom has been obtained in a highly purified condition. The haemolysin fraction has been separated only in a partially pure condition. But experimenting with *Naja Tripudians* (var. monocellate) venom, which contains large amount of haemolysin, it has been possible to separate the haemolysin fraction of the venom in a crystalline form and the crystalline product is 17·5 times more active than the crude venom.

The procedure adopted may be outlined as follows: The venom solution was precipitated at *p*H 2·8 by the addition of 15% sodium chloride and the active principle precipitated was again fractionated by precipitation with 10% sodium chloride at *p*H 4·0. The active principle which was in the solution was precipitated by adjusting the solution to *p*H 2·8 and addition of 4% sodium chloride. The active principle thus obtained was treated with alumina *C* for removing the inert proteins present. The haemolysin solution was further fractionated by ammonium sulphate. The precipitate formed by 0·4 saturation of ammonium sulphate was rejected and the filtrate was further treated with ammonium sulphate until the solution reached 0·6 saturation. The active principle thus obtained was dissolved in normal saline and alkali added till the reaction of the solution was adjusted at *p*H 6·8 and the solution then cooled to 10°C. To this solution solid ammonium sulphate was added up to 0·4 saturation. Then saturated solution of ammonium sulphate was added,

a few drops at a time, till the first formation of needle-shaped crystals. The ammonium sulphate solution was so added that the crystallization was complete within 6 hours. The above product on recrystallization did not show any increase of activity.

By adopting the above procedure also in the cases of binocellate variety of *Naja Tripudians* and *Bungarus Fasciatus* venom crystalline haemolysin was obtained.

46. Studies on haemolysin (lecithinase) isolated from cobra venom. Part II. Purity, *p*H and heat stability and iso-electric point of crystalline haemolysin.

S. S. De, Calcutta.

The crystalline haemolysin obtained by the method described in Part I was found to be homogeneous as determined by its solubility in ammonium sulphate solution. The crystals were also found to be homogeneous by the electrocataphoretic method. Crystalline haemolysin is most stable at *p*H 6·0, and its destruction is more rapid in alkaline solution than in comparable concentration of acid solution. The half inactivation temperature of haemolysin has been found to be 62°C. The iso-electric point of crystalline haemolysin has been determined by micro-cataphoresis of quartz particles coated with crystalline haemolysin and has been found to be at *p*H 8·55. The iso-electric point of haemolysin as determined by cataphoresis in a U-tube was at *p*H 8·61.

47. Studies on haemolysin (lecithinase) isolated from cobra venom. Part III. Molecular weight and composition of crystalline haemolysin.

S. S. De, Calcutta.

The molecular weight of haemolysin has been determined to be 31,800 from diffusion experiments. The estimation of the different amino acids was carried out and it was found that the different amino acids like arginine, cysteine, histidine, lysine, methionine, tyrosine and tryptophane comprise 1/8, 1/9, 1/12, 1/24, 1/36, 1/36 and 1/96 respectively of all the amino acid residues. On examining the ratio and the frequency of the different amino acids it is found that haemolysin molecule must contain at least 288 amino acid residues. The minimum molecular weight of haemolysin as obtained by multiplying the number of amino acid residues by its average residue weight (115·2 gm.) is found to be 33,200. The difference in molecular weight obtained by the two methods is thus about 4%.

48. Studies on haemolysin (lecithinase) isolated from cobra venom. Part IV. Mechanism of action of the enzyme lecithinase (haemolysin).

S. S. De, Calcutta.

By the action of crude *Naja Tripudians* venom and crystalline haemolysin on pure lecithin lysolecithins were produced. Using equivalent amounts of crude venom and crystalline haemolysin the amount of lysolecithin produced by crystalline haemolysin was about twelve times greater than the amount of lysolecithin produced by crude venom. The nitrogen and phosphorus content of the lysolecithin agree fairly well with the theoretical values of nitrogen and phosphorus of lysolecithins derived from stearic acid. The haemolytic activity of crude venom and crystalline haemolysin were determined by titrating the unsaturated fatty acids liberated by their action on lecithin. Considering the titration figures

crystalline haemolysin was found to be fifteen times more active than the crude *Naja Tripudians* venom. The optimum *p*H for lysolecithin formation was found to be at *p*H 7·4. Using lecithins obtained from various sources as substrates it was found that the activity of the resulting lysolecithin depends on the unsaturation of the parent lecithin. The different unsaturated acids present in lecithin are liberated by haemolysin at different rates, clupanodonic acid is most preferentially liberated, then comes linoleic acid, which is followed by oleic acid. Acting on cephalin haemolysin produces lysocephalin, but the activity of the product is less than one-third the activity of lysolecithin. Haemolysin shows specificity for the β-form of lecithin.

49. Investigation on Indian opium. Part II. Preparation and concentration of an oxidizing enzyme from Indian opium.

A. N. DEY *and* R. D. SHARMA, Ghazipur.

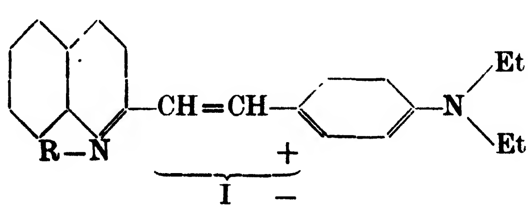
An oxidizing enzyme having action on some phenols as well as on morphine was prepared by extracting freshly produced opium with water, precipitating with ammonium sulphate and dialyzing an aqueous suspension of the gelatinous precipitate obtained against distilled water. The enzyme from the dialyzed solution was adsorbed at *p*H 6 to 7 on tricalcium phosphate gel and eluted at *p*H 5·6 to 6·9 with potassium di-phosphate solution. The operation was repeated giving finally a preparation whose purpurogallin number was 107, indicating a concentration about 1,000 times of the original enzymic preparation.

Industrial Chemistry

50. Photographic sensitizers derived from quinaldine.

M. Q. DOJA *and* DHANUSHDHAR PRASAD, Patna.

In an attempt to prepare a photographic sensitizer suitable for use in the manufacture of panchromatic plates, a set of new sensitizers represented by the general formula (J),



(J)

has been prepared. These compounds have been obtained by the condensation of *p*-diethylamino-benzaldehyde with quinaldine, methiodide, ethiodide, *n*-propyl iodide and *n*-butyl iodide in presence of piperidine as a catalyst. The dyeing, optical, photographic and other properties of these dyestuffs have been examined and recorded. The preparation and properties of quinaldine-*n*-propyl iodide and quinaldine-*n*-butyl iodide have been described for the first time. The future line of research for the synthesis of the proposed sensitizer has also been discussed.

51. The colour of cocoanut fibre.

N. S. VARIER *and* P. GEORGE VARGHESE, Trivandrum.

Although 750 million husks are soaked for preparing coir fibre, little work has been done on its colour which is the criterion on which it is priced. The colour of the fibre varies from golden yellow to dark grey. The cause of this colour is due to a number of factors the chief of them being (1) the nature of the husk; (2) time of exposure prior to soaking; (3) action of rain and sun on the husks before soaking; (4) salinity of the water; (5) nature of retting ground; (6) presence of iron in the water; (7) washing prior to beating the husks. These factors have been investigated.

52. Manufacture of thiourea.

H. K. SEN, Ranchi.

The use of thiourea, both in therapeutical preparations as also in the manufacture of shellac-formal moulding powders developed at the Indian Lac Research Institute, has led to the investigation of suitable sources for this essential chemical. Obviously, its production from calcium cyanamide is the simplest and cheapest, but the unavailability of calcium cyanamide due to war conditions has led the author to investigate the possibility of manufacturing thiourea on a commercial scale from the 'oxide box' liquors of Messrs. The Oriental Gas Company, Ltd., Calcutta. The cost of production from this source is below a rupee per pound.

Incidentally, the method of preparing ammonium thiocyanate by the interaction of CS_2 and NH_3 has been worked out, but the cost of production of thiourea by the conversion of the ammonium thiocyanate by this process is prohibitive, being about Rs.2 per pound on the assumption that carbon disulphide can be produced in this country at four annas a pound.

The author also discusses certain physico-chemical aspects of the conversion of ammonium thiocyanate into thiourea.

Analytical Chemistry

53. Co-ordination compounds of bivalent iron and cobalt with benzidine and *o*-tolidine and a gravimetric method of estimating ferrous iron.

KANAI LAL MANDAL, Calcutta.

Benzidine forms a light brown mono-compound with ferrous sulphate. It is a very stable substance and has the formula $FeC_{12}H_{12}N_2SO_4, H_2O$. It is insoluble in water, alcohol, ether, pyridine, piperidine and aniline. Boiling hydrochloric acid dissolves it quickly and forms a perfectly white water-soluble compound of the composition $FeC_{12}H_{14}N_2Cl_2SO_4$. Hydrobromic and hydriodic acids form similar compounds with ferrous benzidine sulphate. Iron in the form of ferrous sulphate can be very satisfactorily estimated by means of benzidine as the latter gives a quantitative precipitate of the stable mono-hydrate insoluble both in water and alcohol. *o*-Tolidine behaves like benzidine towards ferrous sulphate.

Cobaltous chloride forms two compounds with benzidine. A greenish-blue mono-compound is produced when the constituents are mixed in equimolecular proportions. With excess of benzidine, the pink di-compound is obtained. Both the compounds are stable in air. They are insoluble in alcohol and ether which have no action on the compounds.

Water even in the cold decomposes them. On heating a little, the colour of the di-compound changes to greenish-blue apparently due to the formation of the mono-compound. Cobalt is completely precipitated as cobaltous dibenzidine chloride when excess of benzidine dissolved in a large volume of alcohol is added to a saturated aqueous solution of cobaltous chloride. It suggests the possibility that cobalt can be estimated as a dibenzidine chloride. *o*-Tolidine also gives a greenish blue mono-compound and a pink coloured dicompound with cobaltous chloride, the compounds being similar in properties to the corresponding benzidine compounds.

54. The determination of moisture in salt samples.

R. Ramachandra Iyer *and* K. R. Krishna Iyer, Trivandrum.

A method of determination of moisture in solar salt is given. It is found out in two stages, viz. that given out by heating the powdered salt at 120°C. for 4 hours, termed 'external water' and the other H_2O by difference found out by estimating all other radicles, totalling up and subtracting the total from 100. The justification and advantages of this two-stage determination are discussed and the accuracy of it established by comparison with values obtained by the Karl Fischer titration method.

55. On the estimation of chloro-cresol in solution.

U. P. Basu, Baranagar (Calcutta).

Recently *p*-chloro-*m*-cresol is being largely used as a bactericide for preserving various solutions meant for parenteral administration. A concentration of 0·1% is found to be suitable whereas in cases of phenol and tri-cresol 0·5 and 0·3% concentrations are respectively used. Further, chlorocresol is much less toxic than the other two preservatives mentioned.

The strength of phenol present in any solution can be easily estimated by the usual bromide-bromate method. Tricresol cannot, however, be estimated by this method. In estimating the strength of chlorocresol in various solutions like those in *injectio morphinae* and *injectio quininae et urethani*, it is being found that the usual bromide-bromate method can be easily followed in ascertaining the percentages of chlorocresol present, provided the interfering substances morphine, quinine, etc., are removed by extracting with chloroform after basification with alkali, and a control experiment is made side by side with the test solution.

SECTION OF GEOLOGY AND GEOGRAPHY

President :—J. A. Dunn, D.Sc., D.I.C., F.G.S., F.N.I.

General Geology

1. An attempt at tectonic classification of the Himalayan formations.

K. P. Rode, Guntur.

Last year at the Baroda Session of the Science Congress the author had proposed a tectonic correlation of the formations in Sirmoor Himalayas. The ideas developed therein have been applied to other regions of the Himalayas and a scheme of classification has been proposed which though not very elaborate or final does point to the possible correlations of the various tectonic units developed in the different parts of the Himalayan chain.

The broad tectonic units recognizable in the Himalayas together with their prominent representatives according to the present author are:—

From north to south. Tectonic units.	*Examples.*
Insubrian.	Tibetan zone←Kailas massive.
Trans-Himalayan—Nappes.	(Tibetan Nappes)←Kashmir Nappes.
The central massive.	Gangotri-Nandadevi massive.
Root zone of Lesser Himalayan Nappes.	
Central crystalline Nappes.	Dhauladhar-Almora—Nappes.
Inner Schistose Nappes.	Jutogh Nappes.
Lesser Himalayan Nappes.	Jaunsar Nappes, Krol Nappes.
Para-autochthonous zone.	Potwar—Nummulitic folds.
Autochthonous zone.	Nummulitic zone.
Klippen.	Salt range.

2. On the nature of inter-trappean (Gheru) red-boles and the associated basaltic (Deccan Trap) rock near Poona and Satara, Bombay Province.

N. S. Joshi, Satara.

The paper gives the results of an examination of basaltic rocks and the enclosed inter-trappean boles in Poona and Satara districts with details regarding the nature and structure of the boles; observations on their association with the enclosing rocks have been given. None of these inter-trappeans were found to contain any fossils and few appear to be composed of pyroclastic material. In the opinion of the author the boles have originated from the ancient soils forming the surface prior to the eruption of the overlying lava layers.

The examination has further revealed that the boles are invariably underlaid by weathered trap and the author thinks that it represents the former sub-soil material.

The crushing strength of rocks appears to be the greatest nearest to the possible positions of fissures, and is reduced in hills away from the source, being dependent on the rate of cooling.

Observations are made on the fact that, on slopes of laterite hills, spheroidally weathered basaltic stones are found mixed with laterite soils at a level several hundreds of feet above Deccan Trap hills.

3. Further observations on the river system of Mysore State.

C. S. PICHAMUTHU, Mysore.

In a paper communicated to the Twenty-eighth Session of the Indian Science Congress, a preliminary account was given of the river system of Mysore State. In this paper, details are given of the more important rivers of Mysore and certain conclusions drawn regarding the configuration of the country.

While the majority of the rivers flow either northwards or southwards in agreement with the general trend of the rock formations, there are a few exceptions: the Tunga, Bhadra, and Vedavati flow in a north-easterly direction, and the Cauvery flows in a south-easterly direction. As they run transversely to the strike of the rock formations, these rivers pass through many magnificent gorges and over waterfalls. An explanation is offered for the exceptional direction of flow of these streams.

The paper is illustrated by lantern slides showing the course of rivers in South India and in Mysore State. Four north-to-south profile sections across the gneissic portion of Mysore bring out the fact that the State is not a flat plateau as is commonly believed, but that it is domed in the middle, the axial line of this elevated region running west to east from the Western Ghats right across the Peninsula, and forming the main watershed of Mysore State.

Palaeontology

4. Note on lithology and new fossil fauna of Ostrea limestone near Mohulia (Mayurbhanj State).

B. H. JENA, Mayurbhanj.

In the year 1903-04 P. N. Bose recorded the occurrence of Ostrea limestone near Mohulia, about 2 miles south of Baripada. Ostrea described from this bed were considered to be related to *O. multicostata* Deshayes, and *O. torresi* Phillipi, by Pilgrim. Eames identified certain specimens of Ostrea as *O.* (*crassestea*) *gajensis*. The fossils that were collected from the boring of a well at Baripada and identified as Amphistegina by Pilgrim were considered to be Rotalia by Tipper. The writer collected a cluster of Ostrea cf. gryphoides from an obscure limestone outcrop in the bed of the Burabalang river at Baripada. In his early observation he collected from the limestone outcrop in the same river-bed at Osurdihi (near Mohulia) three shark teeth belonging to the genera Charcarodon and Oxyrhina.

From this limestone which extends over a distance of about half a mile and is almost horizontal, the writer has recently collected, besides some undescribed Ostrea, a considerable fossil fauna comprising lamellibranchs, gastropods, fragmentary bones of vertebrates, fossil crabs, teeth of certan Scombrioid fishes, bits of tail-spines of rays, portions of pectoral and dorsal spines of Cat-fishes and a great variety of shark and ray teeth. Some of the fossil fish-remains have close affinities with those described by S. L. Hora (*Rec. Geo. Sur. Ind.*, Vol. 74, Pt. 2).

Curiously enough nearly all the representatives (though rather in diminutive forms) of the fossils were obtainable from an impersistent gritty clay band which forms a part of the rock formations exposed in the bank of the river at Osurdihi. It lies in between a sandy clay and the whitish clay that overlies the limestone which is underlain by another clay.

As specific identification of most of the fossils and even the generic identification of some have not yet been possible, only tentative correlation on the evidence of the assemblage of fossils has been suggested.

5. Petrified wood from some new localities in Bengal.

A. K. Ghosh, Calcutta.

In this paper the author records three new plant fossil localities in Bengal, viz. Bolopur (Dt. Birbhum), 23° 40′ : 87° 45′; Suri (Dt. Birbhum), 23° 50′ : 87° 40′; and Garhbeta (Dt. Midnapur), 22° 53′ : 87° 20′. In all the cases the specimens are silicified wood. The details of the geology of these areas are not known and the occurrence of these fossils in lateritic alluvium suggests the age of these beds to be Tertiary.

The wood recorded from Bolepur is a Monocotyledon and belongs to the genus *Palmoxylon* and those recorded from Suri and Garhbeta are dicotyledonous. The details of the anatomical characters with photo-micrographs and the geological age of these fossils are described.

Economic Geology

6. On the occurrence of barytes of economic importance in the vicinity of Bhatgaon village, N.E. of Newar, near Katni, Jubbulpore District, C.P.

S. Deb, Calcutta.

Barytes of good quality occurs near the village of Bhatgaon, situated at a distance of about 7 miles N.E. of Nowar railway station on the main Katni-Jubbulpore line.

The deposits contain three different commercial types of barytes:—

(1) Crystalline, transparent variety.
(2) Semi-crystalline, milk white variety.
(3) Reddish variety, coated with iron oxide.

The deposits are extensive in nature and occur in fissure veins, metasomatically replacing the dolomitic country rock of Dharwar age.

The locality where the barytes occurs is situated within a short distance from the famous bauxite deposits of Nowar, Katni. From the field evidence it can be assumed that the deposits have been formed from magmatic waters. The original source of barium was associated with the basaltic lavas which ultimately gave rise on alteration to the laterite bauxite deposits of great economic importance.

The main fissure vein is about 6 feet in breadth and runs for about a quarter of a mile. Several lenticular pockets occur in the country rock on both the sides of the fissure vein. The vein has been traced to a depth of 30 feet. It is estimated that about 50,000 tons of the three grades of barytes may be obtained from these exposures.

A cheap laboratory method of bleaching the stained variety of barytes with HCl (1 : 6) has been evolved and attempts were made to utilize this method on a semi-industrial scale where about a maund of barytes of the stained variety was treated with satisfactory results. This does not, however, completely bleach the barytes but lowers the iron content considerably to meet the special specifications of the barytes for use in glass industry as well as in the manufacture of paints and varnish.

7. Karachi water problem: A plea for the Malir sources of supply.

Maneck B. Pithawalla, Karachi.

The problem of Karachi water supply is now rather old and the present war conditions having made it acute the Municipal as well as the

Military authorities are forced to turn to the Indus river sources. The present paper is a brief criticism of the Indus scheme and puts forth the author's plea that there is enough water in the Malir river basin at present running to waste in the sea which would support a city of double the size of Karachi. On an average, one inch of rain water provides about 15 million gallons of pure water per square mile. The Malir catchment area is about 500 square miles and as the average local rainfall is 7 inches annually, the total amount of water available in the whole basin is about 50,000 million gallons. Out of this some 33%, i.e. nearly 17,000 million gallons of water, are allowed to escape as run-off, leaving as many as 33,000 million gallons in the basin itself, whereas Karachi draws at present only about 3,650 million gallons per year from the existing Dumlotte system of open wells, underground galleries and tube wells in the alluvium. Much can be done by way of cutting other cross and longitudinal galleries, a series of underground trenches and porous bunds at every quarter of a mile near Dumlotte and other terraces and surface dams in the upper reaches of both the Mol and the Khadeji, as the authorities have decided the continuation of the Dumlotte supply in spite of the fresh Indus supply. At the same time the author deplores their decision to seal up the artesian well dug at the confluence of the Bazar and the Malir and makes a few tangible suggestions for A.R.P.

Petrology and Mineralogy

8. Heavy mineral study of Madan Mahal granite, Jubbulpore, C.P.

N. N. Chatterjee, Calcutta.

In the neighbourhood of Jubbulpore town there are two exposures of granite. One is commonly known as Madan Mahal granite from the name of the historic fort of Rani Durgabati which is situated on this granite hill. This occurs to the south-west of the town and is more or less circular in outline and occupies an area of about 9 square miles. The other patch occurs to the north of the railway station of Jubbulpore and has a linear extension in a more or less east-west direction.

The Madan Mahal granite is coarse-grained and is found to be composed chiefly of quartz, felspar, both orthoclase and plagioclase (oligoclase), biotite, hornblende, epidote, etc. Detailed geological account of this area forms the subject-matter of another paper to be published elsewhere.

In the present paper the author has made an attempt to give an idea of the heavy minerals present in the Madan Mahal granite. The specimens of granite collected from the Gangasagar area were crushed, cleaned and subjected to bromoform treatment to collect the heavy minerals. The amount thus separated was 0·144% of the rock. The heavy minerals identified include garnet, zircon, iron ores (magnetite, limonite), tourmaline, biotite, hornblende, muscovite, calcite, epidote, rutile, ziosite, etc. in order of abundance.

The details regarding these minerals are given in the paper.

9. A study of the heavy accessory minerals in the granite-gneiss occurring in southern Ratnagiri district.

W. A. Walwalkar, Poona.

The author has collected ten specimens of fresh granite-gneiss from four different localities, viz. Kankawali, Nagwa, Sawantwadi and Vengurla Peta. These were crushed and the heavy residue was extracted by panning and with bromoform. Biotite was rejected and accessories were mounted in canada balsam. They were studied under the microscope and microchemical tests were also made. The total number of grains of

each accessory were counted in all slides and their relative proportions also determined.

The common accessories are apatite, sphene, zircon, epidote, also conspicuous are orthite or allanite, and the iron ores magnetite, ilmenite and a trace of pyrite.

10. The Jacobsites present in some samples of Vredenburgite are not chemically simple spinellids but belong to a new mineral species.

M. R. ANANTANARAYANA IYER, Bangalore.

In this paper the results of the chemical reactions of four samples of Vredenburgite with numbers 779, 690, 691 and 692 are discussed in detail. It is shown that these, taken along with the fact that Hausmannite is present in some samples, give sufficient evidence to infer that the Jacobsites in the samples are not simple spinellids with varying values for the molecular ratio Mn/Fe and the ratio sesquioxides/protoxides equal to unity but are characterized by the following features:—

1. The molecular ratio Mn/Fe is equal to unity.
2. There is more oxygen than is necessary for a simple spinellid.
3. The differences among the Jacobsites depend only on the amount of the excess oxygen.
4. The general formula for them is
   (*a*) $Mn_3O_4 \,.\, Fe_3O_4$; (*b*) $Mn_2O_3 \,.\, Fe_2O_3$.

11. Pleonaste-bearing peridotites from Mysore.

P. R. J. NAIDU, Bangalore.

On the southern border of the Mysore District fringing the northern boundary of the Nilgiri range of hills, occur a series of peridotites, some pleonaste-bearing and others not. The pleonaste in these peridotites seems to take the place of picotite which has been reported in the type rock lhorzholite. Biaxial silica is interstitial between the olivines. This paper sets forth the optical and chemical characters of the olivine and the genetic significance of the biaxial silica.

12. The recurrence of Kaemmererite in Mysore.

P. R. J. NAIDU, Bangalore.

The schists of the southern border of Mysore contain a chlorite suite of minerals, indicative of the declining phase of a plutonic metamorphism, that was launched by the intrusion of the charnockites. One of the chlorite minerals shows twinkling akin to the character observed in calcite and has a pink pleochroism. The optical characters are tabulated in this paper.

13. The inclusions in the quartz of charnockites.

P. R. J. NAIDU, Bangalore.

Sir Thomas Holland observes that the inclusions in the quartz of charnockites have a definite optical orientation. The examination of the

rocks collected by the writer among the charnockites in the Mysore-Salem-Vellore-Madras axis shows no such orientation. Evidence is set forth from a study of the rocks of Salem that the inclusions are traceable to the disintegration of biotite in the biotite-gneisses of the area.

14. On the nomenclature of a blue amphibole from Mysore.

P. R. J. NAIDU, Bangalore.

In Vol. XI, No. 5 of *Current Science*, May 1942, pp. 192-193, was reported the occurrence of pargasite in Mysore. As the chemical and optical characters of this blue amphibole are very distinctive, discussions are sought at the Science Congress for naming this mineral.

15. The application of Von Fedorov's crystallochemical analysis to certain derivatives of β-resorcylaldehyde.

P. R. J. NAIDU, Bangalore.

In Vol. III, No. 1 of the *Mysore University Journal*, pp. 50–54, some preliminary optical characters of these derivatives were published and their identity was established. Further optical and goniometric results are discussed in this paper.

16. Study of the microperthites from the alkaline rocks of Sivamalai.

A. P. SUBRAMANIAM, Benares.

Following the lines of investigation suggested by Alling, the perthites, which constitute the bulk of the alkali felspars in the syenites of Sivamalai, were studied with special reference to the shape, size and distribution of the blebs in relation to the enclosing mineral. Three different varieties of microperthites and two of antiperthites are clearly recognized, besides hypoperthite which is sporadic. The albite content deduced from the optical data according to the method of Spencer very closely approximates to the values as recast from an available chemical analysis of the mineral.

The origin of the perthites which appear to be partly of exsolution type and partly of replacement type is discussed at length on the basis of microscopical evidence.

17. A chemical and optical study of a variety of nepheline from Sivamalai.

A. P. SUBRAMANIAM, Benares.

Nepheline which occurs as an essential constituent of the syenites forming the main mass of Sivamalai is an almost colourless variety; it shows twinning and gives rather low values for the refractive indices, which were determined by the immersion method and found to be $\omega = 1{\cdot}5252$ and $\epsilon = 1{\cdot}5225$. From the chemical analysis of carefully picked grains of the mineral, it is found to be a variety of nepheline rich in soda and poor in potassium and has the formula $2K_2O \,.\, 15Na_2O \,.\, 18Al_2O_3 \,.\, 38SiO_2$ as computed from the chemical analysis. In this paper the relation between the low potassium content and its optical characters is discussed which corroborates Bannister's view on the relationship between the chemical composition and the refractive indices of nepheline.

18. On the probable syntectic origin of the alkaline rocks of Sivamalai.

C. Rajagopalan *and* A. P. Subramaniam, Benares.

The alkaline rocks of Sivamalai, which were regarded by Holland to be products of pure magmatic differentiation, have lately been closely studied by the authors. The rock association consists of various syenites, granite-aplite and charnockite, with diopside-granulite occurring as lenses in the syenites. The diopside-granulite was probably an impure dolomite moulded to its present state after undergoing various stages of metamorphism. The microscopical and field evidence, such as the rock association mentioned above, suggests that there was first an assimilation of calcic material by the charnockitic magma, and this later on by differentiation gave rise to the alkaline rocks. The occurrence of calcite of primary origin also points to the probable syntectic origin of these alkaline rocks.

19. Petrographical description of the chief types of the alkaline rocks of Sivamalai.

C. Rajagopalan *and* A. P. Subramaniam, Benares.

Eight distinct types are recognized from the alkaline rocks of Sivamalai. Out of these eight, the most notable is the microperthite. The rock is mostly monomineralic and is composed essentially of perthite felspar. It shows an enormous textural and colour variation—the colour from crimson red to greyish blue, and grain size from a fraction of an inch to nearly a foot. Equally interesting is the dark hornblende-syenite where the perthite is conspicuous by its absence. The description of both these types and others are given in the paper along with the analyses of some of the types.

20. Provincial relationship of the alkaline rocks of Sivamalai.

C. Rajagopalan *and* A. P. Subramaniam, Benares.

With the chemical analysis of the alkaline rocks of the Sivamalai area, carried out by the authors and by others, an attempt has been made to elucidate the chemical relationship amongst these rocks as evidenced by the variation and differentiation diagrams based on the Niggli molecular values and the QLM and π values. The trend-lines as discussed in the paper show the characteristics of the Atlantic-suite.

Geography

21. The physiography of the Upper Ganges Basin.

Data Ram Singh, Meerut *and* Maneck B. Pithawalla, Karachi.

The paper deals with the physiography of the Upper Ganges Basin and includes the physiographic regions, which are classified according to the principles of physiographic division, adopted by the Association of American Geographers for the physiographic divisions of the United States of America and by Professor M. B. Pithawalla for the physiographic divisions of the Lower Indus Basin (Sind). These units are fixed for their utility from the points of surface-configuration, soil-fertility, water supply, agricultural products, industrial possibilities, population problem, communications, etc.

The main divisions into Provinces, Sections and Sub-sections are:—

Province.	*Section.*	*Sub-section.*
I. Middle Himalayas	A. Lesser Himalayas (portion) B. Dun Section (portion)	
II. Sub-Himalayan Region.	A. Siwalik Section (portion)	
III. Upper Ganges Valley.	A. Indo-Gangetic Watershed	
	B. The Doabs	(a) Jumna-Ganges Doab. (b) Gogra-Ganges Doab.
	C. The Piedmont Zone (the Tarai and the Duars) D. Trans-JumnaTract	
IV. Rajputana Uplands	A. South-Eastern Section	(a) Chambal Valley. (b) Bundelkhand (portions). (c) Baghelkhand (portions).

They are all differentiated from one another from the points of view of their rock structure, land forms, the process of land erosion by sub-aerial agencies and the recent stage of erosion or deposition of material, thus eroded.

A brief geological history of the Upper Ganges Basin together with the origin of the Ganges Plain has been discussed. The general geology, surface topography, rocks, soils, Kalar lands, ground contours, mineral resources, water resources and drainage of each division are sufficiently dealt with. The Ganges and its tributaries are compared with the Indus system, regarding their regime, discharge, silt deposit, etc.

The paper also attempts a review of the economic resources of each division of the Basin and their future development.

22. Natural vegetation of the Upper Ganges Basin.

DATA RAM SINGH, Meerut *and* MANECK B. PITHAWALLA, Karachi.

The Upper Ganges Basin, agriculturally the richest part of India, affords an excellent example of the geographical control of land on its natural vegetation, which has lost much of its primeval appearance at the hands of Man with the march of time. The flora has also been greatly affected by the process of irrigation.

The extent and position of the Basin and its variety in relief and climate combine to give it a number of vegetation belts, resulting in a great diversity of plant associations.

The flora of the region is classified into (1) grasslands, (2) weeds, and (3) forest zones, each of which has been studied with reference to its own physiographic division. It has been found that the vegetation belts almost correspond with the physiographic division to which they belong.

An attempt has been made to indicate the geographical distribution of natural vegetation with its influence and economic life of the people of the Basin.

23. Contribution of the Zoroastrian community to the growth of Karachi and its environs.

MANECK B. PITHAWALLA *and* BEHERAM S. RUSTOMJI, Karachi.

It is a well-known fact that the Zoroastrians form the smallest single community, not only in India but in the whole world, but at the same time they have given comparatively the largest share possible in the All-India civilization cf the country. The present paper deals with the important contribution the community has made to the gradual growth of Karachi city, its lay-out, Bunder Road extension, institutions, trade and economic welfare for nearly 100 years.

1943 will see the centenary of Karachi, and for its progress particularly the Parsees and Iranis, professing the religion of Zoroaster and numbering 3,700 souls only according to the census of 1941, have really put into practice its tenets in such a way that it has benefited not only the small group itself but also other peoples living in the cosmopolitan city of nearly four lacs. Its poor 'Chawls', middle-class colonies and richly owned private properties besides the various charitable dispensaries, hospitals, educational institutions, public libraries, gymkhanas, health and culture centres, hotels, industrial centres and, above all, its magnificent Kothari Pier and Parade of Clifton, reveal a solid programme of acculturation and pioneering tendencies, worthy of imitation by other Indian cities.

Import and export trade and small industries have been stimulated, barren land has been developed on co-operative lines and for its extension, water supply, sanitation, health and administration Parsee worthies have rendered meritorious services.

These have been recorded in the paper and a map of Karachi and its environs, specially drawn to illustrate these services to the city, accompanies it.

24. Prospects of fisheries and fishing in the Sind region.

G. S. RAISINGHANI *and* MANECK B. PITHAWALLA, Karachi.

The rôle of fish in solving the vital problem of shortage of food and nutrition has now been fully recognized. According to the present investigation, Karachi dominates the marine fisheries and the River Indus and Lake Manchar are the most important inland fisheries. Almost all the fish is consumed locally or despatched to neighbouring markets only. The most important sea fishes are: surmai, boi, rawas, pomfrets, sharks and prawns. The most important river fish is pala and of Lake Manchar is dombhro. All these localities have good fishing grounds, described in the paper.

Fishing is an old industry of Sind but since the construction of the Lloyd Barrage at Sukkur in 1933, the inland fisheries have been impaired seriously. However, there is great need and scope for scientifically developing the fisheries and reorganizing the fishing industry in Sind in order to increase the revenue receipts of the State, to give a fillip to other allied cottage and factory industries and thereby to relieve unemployment and alleviate poverty.

The paper is accompanied by maps, graphs, sketches and photographs.

25. Economic holding in the Punjab.

KAZI SAIEDUDDIN AHMAD, Aligarh.

In this paper, an attempt has been made, on the basis of varied data, to show that the primary factor in the determination of the economic

holding is water supply. Once it is available, other factors come into play, e.g. the fertility of tho soil, the system of farming, supply of capital, accessibility of markets, customs and habits of the people and the local standard of living.

26. Urban geography of Kathiawar and Cutch.

C. D. DESHPANDE, Dharwar.

The Western India States Agency is one of the most urbanized regions of India. Its high percentage of population is primarily due to political fragmentation, defence, and maritime commerce. Recent commercial dovelopment has strengthened this urban growth although in a new form. Influence of modern industry is growing and there are indications that urban growth in future will be mainly restricted to the larger and more favourably situated towns.

SECTION OF BOTANY

President:—K. BISWAS, M.A., D.Sc. (Edin.), F.R.S.E.

Fungi

1. Agaru production by fungal inoculation in *Aquilaria agallocha* trees in Assam.

S. R. BOSE, Calcutta.

In 1925 a fungus (*Cladosporium* sp.) was isolated from the 'Agaru' gum of dead branches of *Aquilaria agallocha* trees, and a short account of the investigation was published in the *Proc. 13th Ind. Sc. Congress*, 1926 (p. 224). Each year, for three successive years from 1939–1941, a dozen mature trees, i.e. 39 mature trees in all, located in the Nambor Reserve of Assam, were inoculated with pure culture of the fungus with the kind assistance of Mr. R. N. De, the Silviculturist of Assam, in the hot and moist weather of the rainy season (June to August). Some of these trees were thirty years old, growing wild in the natural state, while others belonged to the Government plantation. The first lot of 1939, when examined in 1940 and 1941, showed successful production of 'Agaru' gum close to the inoculated areas of the trees. An abundance of the fungal hyphae was noticed in sections of the wood and the 'Agaru' smell was detected in the distillate when the infected wood-pieces in water were subjected to distillation with superheated steam.

2. Suspected symbiosis in *Casuarina equisetifolia* tree.

S. R. BOSE, Calcutta.

Besides parasites and saprophytes, some fungi live as symbionts in higher plants. Almost every wild tree lives in association with a fungus in its roots. The association of *Calluna vulgaris* with a *Phoma* species is a case in point. *Boletus elegans* grows in contact with roots of European larch. In the present case a fungus with weak virulence has been found living intracellularly in the cells of roots, stems, green branchlets, fruits (cones) and seed-coats of normal and healthy *Casuarina* plants of different localities. Seeds both ripe and unripe were collected from different areas of Bengal, Bihar and Orissa; in each case the same mycelium was found in the coat of these seeds. When such seeds germinate, the hyphae present in the coat infect the seedlings of *Casuarina* and normal development takes place. Here there is no formation of ectotrophic or ectoendotrophic mycorrhiza. A close connection between the presence of tannin in the neighbourhood and that of hyphae has been established.

In the case of normal growth of such plants it seems to be a state of well-balanced equilibrium between the two, but sometimes the fungus becomes a virulent one-sided parasite and can kill the plant. The fungus has been isolated in pure culture from dead and dying branches of *Casuarina* trees; though the identity of the fungus has not yet been established, it seems to be a member of the Ascomycetes group. Experiments on the germination of *Casuarina* seeds in the presence of the fungus in pure culture are going on. The probable function of the fungus within the cells of *Casuarina* plants is discussed. Starch contents of healthy and diseased plants have been determined.

3. Storage diseases of potatoes. I. Factors favouring dry-rot of potatoes by *Fusarium oxysporum* Schlechtendahl.

S. C. Agarwala, Lucknow.

This work was undertaken with a view to find out the remedy for the rotting of potatoes in the cold storage plant at Hapur, where a valuable quantity of seed tubers was lost due to dry-rot during the storing season of 1940-41. *Fusarium oxysporum* Schl. and a number of other fungi were isolated from diseased tubers obtained from Hapur. Pathogenicity tests proved that *F. oxysporum* Schl. was the pathogen, as this fungus alone produced the rot in potato. The paper describes the symptoms of the dry-rot of potato tubers and also the effect of temperature, aseptic aeration, etc. on the parasitism of *F. oxysporum* Schl. with special reference to two varieties of potatoes, 'Safeda' and 'Gola', which are commonly grown in the United Provinces.

4. Studies in the decay of fruits in storage. I. Investigation into the causal organisms and sources of infection with a short note on the morphology of the fungi isolated.

S. Sinha, Lucknow.

The paper deals with the fungal organisms responsible for the decay of fruits in storage. Mangoes, apples, pears, peaches, pomegranates, oranges and grapes have been studied in this connection. Fungi occurring on the surface and in the tissues of diseased fruits have been isolated. Ten fungi, viz., *Aspergillus niger*, *A. nidulans*, *A. fumigatus*, *A. tamarii*, *Penicillium atramentosum*, *P. fellutanum*, *Alternaria* sp. (Al 1), *Fusarium* sp. (F 1), *Rhizopus arrhizus* and *Neocosmospora vasinfecta*, have been obtained from the surface. The tissues have yielded 23 strains, of which seven are the same as from the surface and the rest are *Acrothecium penniseti*, *Alternaria* sp. (Al 2), *Aspergillus candidus*, *A. variecolour*, *Colletotrichum capsci*, *Colletotrichum* sp., *Fusarium* sp. (F 2), *Rhizopus* sp. and eight others which have not sporulated so far. Mangoes, apples, oranges and grapes in apparently healthy condition have yielded a few fungi which have also been found from the diseased tissues. Fungi occurring in the atmosphere of local storage places and mango orchards have also been isolated. Many of these are the same as isolated from the fruits.

On comparing the isolations from the different sources enumerated above, two types of infection seem to be evident. The first through wounds, lenticels, etc., causing immediate decay and the second taking place at an early stage of development of the fruit and lying dormant without causing any sign of disease, which becomes evident only when the fruit is mature and ripe.

Infection experiments to test the pathogenicity of the strains have been carried out. The fungi isolated have been described with illustrations.

5. Studies in the decay of fruits in storage. II. On the pathogenicity of certain fungi attacking mango fruits.

S. Sinha, Lucknow.

The work relates with pathogenicity experiments by inoculation method with four fungi, *Aspergillus niger*, *Aspergillus nidulans*, *Colletotrichum capsci* and *Acrothecium penniseti* on two varieties of mango fruits stored at 15°C. and 30°C. The study has been made with a view to find out the effect of temperature, variety and age of fruit on the attacking power of the strains.

The results indicate that the fungi can be arranged in decreasing order of their attacking power. This order is liable to change under the

influence of temperature and maturity of the fruit, the variety of the fruit having no effect. Fruits exhibit varietal resistance, a certain variety being more susceptible to attack than the other by the same fungus. Maturity of the fruit also affects the attacking power of the strain, the pathogen being more virulent in late samples of the fruits than in early ones.

Storage of the fruits at low temperature has been found to be advantageous, since the fruits keep well for a longer period and the amount of damage caused by the storage pathogens is slight.

6. Studies in the Ustilaginales. I. Factors affecting the germination of the spore-balls of *Tolyposporium Pennicillariae* Bref.—A smut on *Bajra* (*Pennisetum typhoides* Stapf.).

R. S. Bhatt, Lucknow.

The paper deals in detail with the various factors affecting the germination of the spore-balls of *Tolyposporium Pennicillariae.* The mode of germination of the spore-balls is either by promycelia or hyphal tubes or both; the last being the most common. Factors such as nutrition, light, temperature and fungicides, etc. were employed.

7. The epispore structure of *Tilletia Ajrekari* Mundkur.

R. S. Bhatt, Lucknow.

The author while working on the life-history of *Tolyposporium Pennicillariae* Bref. obtained three sori of a species of Tilletia mixed with the sori of *T. Pennicillariae.* These were examined in microtome sections 10μ thick. The fungus was tentatively named as *Tilletia Ajrekari* as the description closely agreed with that given by Mundkur (1939) for a new smut on *Bajra* (*Pennisetum typhoides* Stapf.). But as the epispore structure as illustrated and described by Mundkur is somewhat different from that found in the spores under investigation, a complete description of the same is given in this paper.

Algae

8. A critical review of work on Zygnemales in India.

M. S. Randhawa, Rai Bareli.

Work on members of the Zygnemales, done in India, is critically reviewed with special reference to some species of doubtful validity. Practical tips are given for the observation of sculpturing of spore-wall, which is of fundamental importance in the systematic study of this group. An exhaustive bibliography is given in the end of important papers published in India and outside.

9. On the Chlorophyceae of Khandalla and Lonavla.

(Mrs.) E. Gonzalves, Bombay.

Khandalla and Lonavla are two stations within easy distance of one another, and situated near the top of the Bhore Ghat at an elevation of 2,000 feet above sea-level.

A large collection of algae consisting mostly of members of the Chlorophyceae was made during the monsoon of 1941, and about 40 forms are described from the collection in this paper.

10. Studies in the periodicity of the algae in a tank and a pond near Bombay.

(MRS.) E. GONZALVES *and* (MISS) D. B. JOSHI, Bombay.

The ecological factors operating in two pieces of water and influencing algal growth are described in this paper. In all, 103 algal species from a tank and 157 species from a pond near Bombay are recorded. In the tank greater development of the algal flora quantitatively is found, whereas in the pond qualitative development of the algae is more evident.

From the seasonal study of the algae, the factors that cause, modify and direct their growth are determined and by comparing the time of the appearance of the forms common to the two pieces of water, the local conditions of weather and water favourable for the growth of these forms are also determined.

11. Algal flora and fish fauna.

K. BISWAS, Calcutta.

A large number of marine and freshwater algae supply food to fishes. Minute organisms, mainly crustacea, live upon marine and freshwater plankton. These algae contain large quantity of oil and many commercial fishes of the sea living upon crustacea, which in their turn subsist on *Microphyto-plankton* flora, are very rich in oil content. Sometimes the change in the flow of plankton due to temporary deviation in the oceanic current alters the course of fishes as well. In our static and dynamic waters in India, quite a large number of common species of algae mainly belonging to Myxophyceae, Chlorophyceae and Diatomales supply food to edible fish. Records have been made of various species of edible algae obtained from the examination of the gut contents of fishes growing in our tanks, salt and brackish water lakes and the torrential Tista river in the Sikkim Himalaya which is famous for game fishes.

12. Algae of the rice-fields of the Punjab.

SHAMS-UL-ISLAM-KHAN, Lahore.

An ecologico-physiological study of the algae of rice-fields of the Punjab has recently been undertaken. Collections were made at different times of the year from many different fields separated from one another by a distance of two miles.

Algae appear in about two or three days after the fields are flooded with water. Fields with clayey soils are heavily infested with algae as compared with those having loamy or sandy soils.

13. Marine algae from Karachi. Part II: Rhodophyceae.

P. ANAND, Lahore.

The algae dealt with in this paper were collected during an ecological study of the algal flora of Karachi in December 1936, April 1937 and April 1938. The most important communities formed by the Rhodophyceae in the rocky ledge at Manora are the *Gelidium-Polysiphonia*-community and the *Hypnea-chrysmenia*-community. About 60 species of Rhodophyceae are mentioned in this paper. They include three new species and seven new records for Karachi.

Hepatics

14. Some further observations on the epiphyllous Hepaticae of India and Ceylon.

S. K. PANDÉ *and* S. AHMAD, Lucknow.

In the earlier two papers of this series (*vide* Misra, R. N., *Proc. Ind. Sci. Cong.*, 1939, and Pandé and Ahmad, *ibid.*, 1942, p. 144). The species of epiphyllous liverworts were recorded. In the present paper eight additional species are described.

The paper gives a detailed taxonomic account of the new species and some features of interest of the others.

Floristic

15. Observations on Indian Cardamines.

K. BISWAS, Calcutta.

Considerable confusion exists with regard to the systematic position of Indian Cardamine belonging to the family of Cruciferae. The need for a detailed study of the genus Cardamine was stressed by the late Father E. Blatter during our scrutiny of the different forms of Cardamine, particularly *C. hirsuta* and *C. subumbellata* found growing on the Mohaballeswar Hills. About 330 species of Cardamine are recorded so far. Of these, 116 species have been dealt with critically by O. E. Schulz in his 'Mongraphie der Gattung Cardamine' published in Engler's *Botanische Jahrbücher*, Vol. 32, pp. 280–623, 1903. Detailed examination of the sheets in Calcutta, Kew, British Museum (Natural History), London and Edinburgh Herbaria reveals that there are 13 species of Cardamine indigenous to India. One new species has been discovered which has been named *Cardamine Smithiana* Biswas. This species was collected from Dongala, Tibet, by F. Ludlow and G. Sherriff in 1933, type No. 324, Herbarium, British Museum (Natural History), London.

66·66% of the species of Cardamine occur in the Northern Hemisphere and 33·33% in the Southern Hemisphere. Of these, 33·33% are represented from Asia, 24·24% from South America, Europe 15·15%, North Africa 1·81%, Australia 3·33%, New Zealand 2·42%, South Africa 0·606% and other parts of the world 5·45%.

Ecology

16. Invasion and migration of grasses on ploughed and unploughed enclosed areas of Usar soil.

S. N. DAS GUPTA *and* S. N. ASTHANA, Lucknow.

The present paper deals in detail with the invasion and migration of grasses from an unploughed to the ploughed area and also within a ploughed area. For this study Line Transect and Belt Transect methods were employed.

The results show that the grasses which were present during summer extended their areas during rains. The grasses that had died out revived their old root stocks and new species which were absent during summer came up. There is thus not only regeneration of grasses in the areas previously occupied by them but also there is an advance of grasses into the neighbouring open areas.

17. Regeneration of grasses on Usar soil.

S. N. DAS GUPTA *and* S. N. ASTHANA, Lucknow.

The present investigation was undertaken to find out the effect of enclosure and ploughing on the regeneration of grasses on Usar soil. The experiments were carried out and observations made in a grass farm consisting of about 150 acres of Usar land. Part of the land was ploughed by different tractors leaving the rest unploughed and the whole area was then fenced to allow undisturbed growth of plants in the differently ploughed and unploughed areas.

For comparison of grasses growing inside the enclosure with those growing outside where grazing was freely occurring, an extensive collection of all the grasses was made during different times of the year and identified.

Economic Botany

18. A review of the progress in economic botany in Burma.

D. RHIND, Darjeeling.

A brief outline of the achievements in the improvement of the principal crops of Burma during the past twenty years is given. Some 70 improved lines of rice were under distribution from Government Farms in 1941, including two hybrids. Investigations on the causes of milling breakage have led to improvements in methods of drying grain. Two physiological races of sesamum have been distinguished and breeding work on long-day types has led to notable increases in yield, oil content (up to 60%), and resistance to phyllody. Cotton breeding has yielded types with better staple and yield while agronomic trials have much improved the treatment of this crop under dry conditions. The introduction of Indian and Javanese sugarcanes has raised the average yield of this crop fourfold. Amongst the numerous cultivated beans of Burma *Phaseolus lunatus* Linn. has been improved by hybridization to give types of high yield and very low prussic acid content. Pigeon Pea (*Cajanus cajan*) has been developed as an intercrop with cotton, sesamum and ground-nut and types with large white seed and habit suitable for the different associated crops have been bred. A variety of gram from Karachi proved entirely resistant to 'Wilt' disease and its introduction led to a large increase in this crop. Gram as a follow-on crop after rice has been developed. Sorghums resistant to *Striga* attack have been found. Other crops dealt with are ground-nuts, tobacco, potato, wheat, tung and maize. The review concludes with a note on systematic botany in Burma and the need for a flora of that country is stressed. Nearly all improved strains are now under maintenance in India.

19. Tung oil-yielding plants of India.

K. BISWAS, Calcutta.

Tung oil-yielding species are known to India for more than a century. Aleurites moluccana is recorded by Roxburgh in his *Flora Indica* and specimens of this species were collected from Sylhet by N. Wallich about 114 years ago.

The true tung oil-yielding plants are mainly *A. fordii* and *A. montana*. Five species of Aleurites are so far known. All these yield some kind of drying oil which is of great commercial value. The true tung oil-yielding plants were introduced and cultivated in the Royal Botanic Garden for a period of 50 years. In the last quarter of a century special attention has been paid in Burma and India towards cultivating the tung oil-yielding trees on a large plantation scale from seeds distributed

through Kew and Royal Botanic Garden, Calcutta, for commercial exploitation of the oil. The meteorological and biological conditions controlling the growth of the different species in relation to the production of fruits are discussed in the paper. It has been found as results of experiments in India that *A. montana* is the most suitable species to grow in India for the tung oil.

Fossil Botany

20. Spores and sporangia from the Jurassic of India.

A. R. Rao, Lucknow.

In 1936 the presence of 2-winged and 3-winged spores, scattered in the matrix of some silicified blocks from Nipania (Rajmahal Hills, Bihar), was reported and some of them were referred to the form genus *Pityosporites* (Rao, *Proc. 23rd Ind. Sci. Cong.*, 1936). Further examination of the same blocks has revealed some other types of spores and sporangia and these are figured and described in the present paper. A new form genus *Podosporites* is instituted for microspores with three bladdery wings as in some modern Podocarpineae. The wings are elliptic in form and are grouped on the ventral side, the spore body projecting hemisphere-like on the dorsal side. The wings are reticulately sculptured and the spore wall is granular.

The existence of Podocarps in the Rajmahal flora has been suggested by Sahni and by Florin after a study of cuticular preparations, vegetative shoots and strobili from this area. Although no actual attribution can be decided, yet the occurrence of these 3-winged microspores tends to confirm the above suggestion.

21. On two new spp. of petrified gymnospermous woods from the Chhindwara district, C.P.

V. B. Shukla, Nagpur.

In this paper are described two silicified woods (*Dadoxylon* sp. nov. and *Cupressinoxylon* sp. nov.). The *Dadoxylon* differs from all the other known species of this genus and like *D. Deccani* Shukla shows the interesting feature of the combination of alternate and opposite pits. This wood may, hence, be considered as a connecting link between the Abietineae and Araucarineae. The *Cupressinoxylon* has also been found to be different from all the other species, known so far, but shows considerable resemblance with *C. alternans* Sahni from which, however, it differs in the biseriate nature of the medullary rays, the absence of well-marked growth rings and a few other features.

The exact locality and age of the woods are not known, but they are stated to have been found somewhere in the Chhindwara district, and they may possibly have come from an Intertrappean horizon.

Anatomy

22. Floral anatomy of the male flowers of *Myristica fragrans*, with special reference to the origin of the trimerous perianth.

A. C. Joshi, Benares.

The 3-lobed tubular perianth of *Myristica fragrans* is supplied by ten traces from the thalamus stele. This shows clearly that the trimerous condition has been derived from a pentamerous perianth. The com-

parative size of the different perianth segments shows that the change has been brought about probably by the complete fusion of the four anterior tepals in pairs.

23. Origin of adventitious roots in the hypocotyl of *Cucurbita maxima*.

GIRIJA P. MAJUMDAR, Calcutta.

In the hypocotyl of *Cucurbita maxima* the vascular bundles numbering about 10 are arranged in a single ring around a comparatively wide pith the central region of which often becomes hollow with age. The outer vascular cambium is many-layered and extends up to the primary rays on both flanks of the bicollateral bundles each of which is characteristically surmounted by a sclerenchymatous bundle cap, particularly in the lower region of the hypocotyl.

The adventitious roots begin their appearance near the base of the hypocotyl and extends upwards. The root initials take their origin in the cambium cells adjoining the primary medullary rays, the ray cells abutting upon the cambium also take part in their formation. There may be two adventitious roots on the two sides of a vascular bundle or, rarely, two root initials proceeding from the opposite flanks of contiguous bundles may unite in the middle of the intervening primary ray to form a single lateral root. The root primordium after its organization turn through 90 during its progress through the cortex towards the periphery of the hypocotyl. During this process of initiation of an adventitious root and its course through the cortex the original position of the bundle cap is not, or is very slightly, disturbed.

Thus the origin of adventitious roots in the hypocotyl of *Cucurbita maxima* is in the vascular cambium near to the side of a vascular bundle in the formation of which ray cells also take part. This conforms to the second of the two types of origin of shoot-borne adventitious roots described by Priestley and Swingle and illustrated in the hypocotyls of *Helianthus* and *Ricinus* and in the epicotyls of *Vicia* and *Solanum*.

24. On the multiperforate plates occurring in the xylem vessels of some monocotyledonous plants.

B. C. KUNDU, Calcutta.

The occurrence and structure of multiperforate plates in the xylem vessels of the roots of some monocotyledons are described. Such plates are present in all the vessel segments of the roots of many members of the family Araceae and in *Crinum asiaticum* Linn. In all these plants vessel segments with simple perforations have not been observed. The vessel segments as found in those roots may be of three types: (i) those having oblique end walls at both ends; (ii) those having oblique end wall at one end and transverse or slightly inclined end wall at the other; (iii) those having transverse or slightly inclined end walls at both ends. The perforation plates of these segments may be scalariform, scalariform with branched bars, or reticulate. The bars of the plates can be correlated to the scalariform-reticulate thickening of the lateral walls of the vessel segments.

These types of vessel segments are regarded as to form a primitive feature. Further it is concluded that the xylem vessels of roots have developed phylogenetically from typical scalariform tracheids by the loss of pit-membranes at their ends, and in this respect the writer supports the views expressed by Frost (1930, 1931) in connection with the development of vessels of arboreal dicotyledons.

25. Studies on Indian xerophytic species of *Selaginella*.

N. CHOWDHURY, Lucknow.

The physiological anatomy, distribution and general morphology of xerophytic species of *Selaginella* in India, Burma and Ceylon have been studied. The material for anatomical investigations consisted mainly of *S. bryopteris* Bak. and *S. Wightii* Hieron. representatives of the groups of 'lepidophylla' and 'rupestris' respectively.

26. Structure and development of lenticels in fruits of *Mangifera indica* Linn.

S. SINHA, Lucknow.

The investigation deals with the structure and development of lenticels in mango fruits of three varieties, viz., Bombai, Safeda and Dasohri.

The structure of the lenticels has been described in detail and compared with that of stem lenticels of angiosperms. In general features the two types are alike but the periderm so characteristic of stem lenticels is lacking in those of mango fruits. The origin of lenticels has been traced to stomata and the structure of the latter has been described in detail. The stages in the development of lenticels from stomata have also been studied. All the stomata do not develop into lenticels. As the fruits mature some of the lenticels become closed while others remain open, the closure being affected by the development of a layer of cuticle on the outside of the outermost layer of hypodermal cells.

The distribution of lenticels as indicated by counts per unit area has been studied.

27. A note on the anatomy of some of the Convolvulaceae.

M. SAYEEDUD-DIN, Hyderabad-Deccan.

The comparative anatomy of the petiole, stem and leaf of the flowering members of the family CONVOLVULACEAE has been studied: *Argyreia speciosa* Sweet, *A. cymosa* Sweet, *Ipomaea repens* Lam., *I. Pes-tigridis* Linn., *I. sepiaria* Koen, *I. pentaphylla* Jacq, *I. Tridentata* Roth, *I. Horsfalliae* Hook, *Quamoclit pinnata* Boj. (1) In all the species of *Argyreia, Ipomaea* and *Quamoclit* vascular bundles are bicollateral. (2) Isolated secretory cells occur in most of the species. (3) In all the cases stomata are accompanied by two subsidiary cells placed parallel to the pore of guard cells. (4) Clothing hairs are 2-celled. (5) Glandular hairs occur in some of the species. (6) Oxalate of lime occurs in the form of clustered or solitary crystals. (7) An anomaly in the structure of the axis is revealed by the presence of bands of wood on the outer side of the intraxylary phloem in *Argyreia*.

Physiology

28. Photoperiodic studies in rice.

S. M. SIRCAR, Calcutta.

Experiments on photoperiodic response in winter paddy have been carried out for the last three years and the following results are recorded: 6, 8 and 10 hrs. photoperiods were given to rice seedlings in seed beds. The treatment was begun when the seedlings were 7 days old and continued for 2, 3, 4, 5 and 6 weeks and the seedlings were subsequently transplanted in pots. There were also control plants having normal day lengths. Tiller counts at intervals show that all the tillers are not fertile, a number of sterile tillers are noticed in 6 hrs. and control plants, while

treatments with 10 and 8 hrs. light for more than 4 weeks produce very few sterile tillers. The plants given 10 hrs. exposure for 6, 5, 4, 3 and 2 weeks show an average earliness of 13, 10, 13, 9 and 9 days respectively. With 8 hrs. light for the same number of weeks an average earliness of 10, 10, 11, 9 and 6 days respectively is obtained, while 6 hrs. photoperiod for 6 and 5 weeks only induces earliness of 8 and 6 days. The grain yield in 10 and 8 hrs. plants show an increase over the control and 6 hrs. plants.

In another set of plants when the same photoperiods (6, 8 and 10 hrs.) were continued till ear emergence, earliness of 28, 25 and 22 days respectively were observed. Six hrs. treatment, although inducing earliest flowering, brings out defective grains; consequently the total yield as compared with the control is much reduced, while in 10 and 8 hrs. light it is greatly increased.

29. Nitrogen metabolism in rice leaves.

NIRAD KUMAR SEN, Rajshahi.

The paper deals with the nitrogen metabolism in the successive mature leaves of rice, grown in soil under optimum cultural condition. A gradual decrease in the concentration of the total nitrogen in percentage of dry weight has been observed in the successive leaves, mainly due to simultaneous increase in total dry matter, in much greater proportion. Protein nitrogen concentration varies directly with total nitrogen, but while expressed as percentage of total nitrogen, it increases in the successive leaves, indicating increased metabolic activity in the later leaves. Rice plants are characterized by low conc. of amino and amide nitrogen. On transplantation a rapid uptake of nitrogen is noticed in the 7th and 8th leaves. This is followed by an increase in protein, amino and amide nitrogen fractions and a vigorous vegetative growth in height and tiller. In the 14th leaf, when the ears are just emerging, translocation of organic nitrogen to this rapidly developing region is indicated by decrease in protein nitrogen and increase in soluble fractions, specially amides and amino acids.

Miscellaneous

30. Viviparous germination in *Pennisetum typhoides* Stapf.

R. S. BHATT, Lucknow.

During the course of the investigations on the life-history of *Tolyposporium Pennicillariae* Bref. the author came across the phenomonon of viviparous germination in two ears of *Bajra* infected with the smut *T. Pennicillariae.* The seedlings produced from the uninfected healthy seeds were at different stages of maturity. The germination of the seeds appeared to be normal. The shoots grew out into the air whereas the roots penetrated in the cavities of the neighbouring spikelets or the smut sori or hanging down. The maximum length attained by the shoot was 98 mm., and that by the root about 32 mm. A few roots that had entered or were in contact with the ruptured sori were examined in sections but none of them gave any trace of the mycelium. One of the ears that was kept under observation in the field showed that the seedlings had dried up after they had attained a height of about 133 mm.

31. A new microtome attachment for safety-razor blades and for overcoming difficulties associated with microtomy.

N. K. TIWARY, Benares.

The attachment here described is in the form of a small metal tank with arrangement for gripping a safety-razor blade and for continuous

flow of water. There is, moreover, an arrangement for keeping a slide while the sections are being cut, and keeping it *just* submerged.

The gadget has been found to solve *all* microtomic difficulties: (1) It holds a safety-razor blade rigidly: the blade can be adjusted to give a number of fresh cutting-edges. (2) It prevents electrification by bringing the sections, as they are cut, *immediately* in contact with water on which they begin to float. (3) Wrinkling of the sections is prevented by their becoming forthwith stretched. (4) Temperature can be maintained at any desired degree by introducing water of the required temperature and maintaining a continuous current. Sections of any desired degree of thinness or thickness can be made without the least difficulty *at any time of the day and during any season.* (5) A continuous ribbon is produced and this floats gently into position on the slide where pieces of suitable length can be cut and immediately arranged. By this means triplication, or even quadruplication, of manipulations involved during a series of processes is avoided, and the entire operation is accomplished *in one step.* Besides circumventing the difficulties a large economy in time is secured.

The attachment is 4″ long and from 1″ to 1⅓″ wide at its two ends respectively. It can be made easily and costs little.

32. Observations on the shedding stage of pollen in some Angiosperms.

N. K. Tiwary, Benares.

Very meagre information is available on the shedding condition of the pollen, i.e. whether it is 2-nucleate or 3-nucleate, and whether sperm cells have already been organized in the pollen grain itself or only sperm nuclei are present. This knowledge besides being of purely academic interest can also be, as it has sometimes been, utilized in many cases for disentangling systematic relationships. The present paper describes the author's observations on a number of local plants.

33. Notes on the germination of pollen grains in artificial media.

N. K. Tiwary, Benares.

A knowledge of the longevity of the pollen is not only useful from the academic point of view, but is also necessary for practical purposes in connection with the crossing of species from two widely separated regions by transporting their pollen. For this purpose it is necessary to study the germinating capacity of stored pollen. As a necessary preliminary, experiments are necessary to determine the most suitable medium and its optimum strength to induce germination. A list of plants giving the most suitable strength, in each case, of the media used is given. It was also necessary to devise and develop a new technique which is described.

34. On the structure and germination of the fruits and seeds of *Zizyphus jejuba* and *Martynia diandra*.

N. K. Tiwary, Benares.

In this paper are recorded the author's observations on the structure of the above-mentioned fruits and seeds. A description is given of some interesting features in the germination of their seeds, which, in both cases are enclosed either in a hard stony or woody case representing a part of the fruit wall.

SECTION OF ZOOLOGY AND ENTOMOLOGY

President :—B. N. CHOPRA, D.Sc., F.N.I.

Protozoa

1. On a new flagellate, *Pentatrichomonas alleni* n.sp., from the intestine of the Himalayan crow, *Corvus corax tibetanus* (Hodgs.).

H. N. RAY *and* S. N. SAPRE, Mukteswar.

In this paper the authors describe in detail the morphology of a flagellate, *Pentatrichomonas alleni* n.sp. which they encountered in the intestine of crows shot at Mukteswar during August, 1942. Briefly the morphology is as follows: The organism measures 7·0μ to 11·2μ in length and 2·8μ to 4·2μ in breadth; the nucleus is situated at the centre of the body or slightly above it; there are five free flagella, the fifth one being independent of the other four grouped together; the undulating membrane is ill developed; the axostyle is represented by a thin axial fibre. It is proposed that *Pentatrichomonas* should be raised from the sub-generic to the generic rank.

2. Observations on two new Coccidian from the intestine of the turtle *Trionyx gangeticus* Cuv.

A. B. KAR *and* M. CHAKRAVARTY, Calcutta.

Two new species of *Eimeria* were encountered in the intestine of the turtle *Trionyx gangeticus* Cuv. Life-history of these species has been described in detail.

Myriapoda

3 Morphology of the alimentary canal and associated glands of the millipede, *Ktenostreptus specularis*.

M. B. LAL, Lucknow.

The mandibles are the chief organs for masticating food. Food is first reduced to a fine state of division by the mandibles moving forwards and outwards and is later on swallowed by a backward movement of the mandible. The narrowest part of the alimentary canal is the oesophagus which has thick walls and is provided with six longitudinal bands on the inner side. The fore-gut is the longest portion of the alimentary canal. At the posterior end of the fore-gut lies a thick-walled bulbous structure and just at the beginning of this bulb on the lateral sides are attached a pair of malpighian tubules, one on each side. The hind-gut is the broadest part of the alimentary canal and is followed by the rectum. Various glands associated with the alimentary canal have been found out. One of these is a pair of large glands extending along the entire length of the oesophagus on its lateral sides. These glands open by separate ducts

into the buccal cavity at the base of the gnathochilarium. They secrete a white sticky fluid which helps in mastication of food and is probably digestive in nature.

4. The heart and arterial vessels in the millipede *Thyroglutus malayus*.

M. B. LAL, Lucknow.

In the present paper it is attempted to give a general account of the blood supply in the millipede, *Thyroglutus malayus*. The heart which is a tubular structure lies embedded in the fatty tissue of the animal dorsal to the alimentary canal. It is segmented and each segment or chamber of the heart bears a pair of lateral openings from which arise two pairs of arteries. The openings lie at the extreme anterior ends of each segment; so that out of the two pairs of vessels which arise from a single opening, one pair goes to the segment of the body bearing the openings and the other pair to the preceding segment. These lateral vessels branch into several smaller vessels at the level of the stink-glands and these branches supply the structures present in each segment. At the anterior and the posterior end of the body, the heart forks into four and two branches respectively. Details of the blood supply are given in the paper which will be illustrated with lantern slides.

Crustacea

5. Preliminary observations on the occurrence of a new species of Rhizocephala on *Neptunus pelagicus* from Madras coast.

A. I. GEORGE, Madras.

A study of the nature of the parasitic castration brought about by this parasite has been made from a collection of 519 crabs of which nearly 20% were infected. The percentage of infection is higher in the males than in the females. Scarred crabs or recovered crabs were not obtained. Only crabs under 25 mm. carapace length are infected, and the life-history of the parasite is correlated to that of the host. The endoparasitic life probably lasts about nine months. Evagination of the parasite takes place during an ecdysis of the host. Other details of the parasitic castration, which is far-reaching, are given.

6. On three species of Bopyrid isopods from South India.

S. NATARAJ, Travancore.

Three species of Bopyrid isopods were obtained while investigating the prawn fauna of Travancore. These are *Epipenaeon japonica* Thielemann, *Palaegyge bengalensis* Chopra and *Palaegyge pica* Chopra. This is probably the first record of the occurrence of the first two species in South India. *P. bengalensis* which is hitherto known to be parasitic on *Palaemon malcolmsonii* and *Palaemon carcinus* is also seen for the first time to be parasitic on a third species, viz. *Palaemon idae*.

The host distribution of the present forms is entirely different from that recorded so far for these species and the present records serve as further examples of the multiplicity of hosts among Indian Bopyrids.

In addition to the facts already recorded by Chopra, it has been found that the presence of the parasite leads to the total degeneration of the posterior 2 or 3 and a partial degeneration of the anterior gills of the infested side.

Mollusca

7. A note on the development of the alimentary canal in *Pila*.

S. Nagaraja, Annamalainagar.

In the early stages of development the alimentary canal consists of (i) a short stomodaeum leading to (ii) a very large endodermal sac, and (iii) a very short hind-gut. This large endodermal sac or albumen sac is an embryonic organ, and superficially resembles a similar structure seen in the development of land pulmonates. The dorsal endoderm is represented by a very narrow streak of cells commencing from the stomodaeum and running obliquely towards the posterior end of the gut.

The mid-gut develops at a little later stage as an outgrowth of the posterior end of the endodermal sac. As the mid-gut develops, the albumen sac begins to shrivel, and finally disappears, as a result of the phagocytic activity of an enormous number of 'nuchal cells' like those observed in the development of Pulmonates. The mid-gut is at first merely a continuation of the endodermal sac. Later, by the formation of cubical epithelium in continuation with that of the hind-gut, the stomach is differentiated. The narrow streak of cells in the dorsal part of the endodermal sac extends now to the stomach and becomes the oesophagus. The digestive gland arises as two rudiments growing out from the stomach.

8. On the bionomics of the Sacred Chank, *Xancus pyrum* (L.)

D. W. Devanesen *and* P. I. Chacko, Krusadai (Madras).

A method of opening the shell and setting the soft body free and unhurt for laboratory studies developed and perfected for the pursuit of this investigation is described. Altogether 325 specimens were dissected during the years 1940-41 and 1941-42. Their diameter ranged from 20 to 113 mm. and their length from 42 to 220 mm. In measuring the length of the shell, that of the protoconch was omitted, for only 25 to 27% of the adult shells retain it. That the fertilization takes place within the oviduct was confirmed by the observations made in five instances when spermatozoa were found along with ova in the albuminous fluid in the oviduct of the female. The distension at this period of the oviduct and the disposition of its thick walls are highly suggestive of the Ram's Horn which in all probability is produced by the oviduct, which, therefore, functions more as a potential uterus than as a duct. The breeding season generally commences in November of one year and closes in April of the following year. The period of incubation of the Ram's Horn has been roughly estimated as nearly six weeks.

9. Some observations on the bionomics of the slug *Laevicaulis alte*.

M. B. Lal, Lucknow.

Laevicaulis alte is fairly common in and about Lucknow. The animals frequent swampy shady areas where green vegetation is plentiful. The body is arched on the dorsal side which is dark grey or black, the ventral side being paler in colour. The animals can climb up steep walls, stems of trees, smooth glass surface, etc. During locomotion the body is fully stretched out and so are the tentacles and the palps. The animals show a kind of creeping or gliding movement which is accomplished by the contraction of the ribbon-like foot. Locomotion is slow. The slime produced by the animal forms the characteristic slime-trail during locomotion and this looks silvery shining on drying. The animals can take all types of food; the castings are thrown out in the form of thread-like pieces. Observations have also been made on the reactions of these

animals to various stimuli. The animals are hermaphrodite and in copulation a pair of mature individuals come to lie on their ventro-lateral sides and show a semi-lunar flexion of their body with their anterior ends in opposite directions. Copulation normally is mutual and reciprocal. The eggs are laid in cocoons generally in places away from sunlight.

Pisces

10. On the alleged existence of races in the population of the Oil-Sardine, *Sardinella longiceps*, in the Arabian sea.

D. W. DEVANESEN *and* K. CHIDAMBARAM, Krusadai (Madras).

The material examined consisted of (i) 124 specimens from Bombay and Karachi, (ii) 61 specimens from Karwar, (iii) 20 specimens from Muscat, and (iv) 110 specimens from Aden. The Karwar Oil-Sardine has the longest head and after that in serial order follow Aden, Bombay-Karachi, Muscat and Malabar Oil-Sardines. The Karwar group has the shortest tail; then follow in serial order, Aden, Malabar, Bombay-Karachi and Muscat. The Karwar Oil-Sardine combines the longest head with the shortest tail. It is likely that the Karwar group belongs to a distinct race wedged in between the Southern Malabar race and the Northern Bombay-Karachi race, which in turn separates the Muscat race from the Indian West-Coast races. The Aden Oil-Sardine having the second longest head and the second shortest tail may be an outlying race by itself.

An additional study was made of the variants of the number of rays in the right pectoral, the dorsal and the anal fins.

Observations based on the above characters lead us to tentatively conclude that in the Oil-Sardine populations of Malabar, Karwar, Bombay-Karachi, Muscat and Aden, more than one race is present.

11. On the bionomics of the Rainbow Sardine, *Dussumineria hasseltii* (Bleeker).

D. W. DEVANESEN *and* P. I. CHACKO, Krusadai (Madras).

The Rainbow Sardine, *Dussumieria hasseltii* contributes to the commercial fisheries of the Gulf of Manaar. Its diet consists mainly of plankton and occasionally of fingerlings of the White-Bait. Specimens 13 to 15 cm. in length form the commercial catches. Sexual maturity seems to be attained for the first time when the fish is 14 cm. in length. The breeding season extends usually from March to December. There seems to be a lunar periodicity in spawning. The left gonads are suppressed. The mature ovarian egg measures 0·84 mm. in diameter. The eggs found in the plankton measured 0·88 mm. in diameter. The yolk is clear and frothy. There is a single yellowish oil-globule at the vegetative pole. The following characteristics were noted in the developing larvae which hatched in the laboratory: (1) the forward migration of the tail myotomes and a corresponding increase in the length of the trunk, (2) the coincidence of the complete using up of yolk and the eyes becoming pigmented, (3) the single oil-globule disappearing by breaking into smaller ones, and (4) the larva showing a widely gaping mouth with a strong dentition.

12. On the possibility of artificial culture of marine mullets in freshwater tanks.

D. W. DEVANESEN *and* P. I. CHACKO, Krusadai (Madras).

Of the fry of three species of mullet found in the tidal pools and creeks in the neighbourhood of Krusadai Island, those of *Mugil troschelii* chiefly

were subjected to four experiments in acclimatizing them to fresh water. In the first three experiments, the fry were brought into fresh water, through gradually decreasing strengths of salinity while in the fourth experiment, they were transferred directly from the sea into fresh water. The casualty in the last experiment was 52%. The second and third experiments in which the casualty was negligible appear most suitable. Previous conditioning in seawater of decreasing salinity is necessary before transplantation into freshwater tanks. Capacity of acclimatization, rapidity of growth, non-cannibalistic habit and the availability of the fry in large numbers indicate that the marine mullet is the best Indian sea-fish for freshwater cultivation.

13. On the developmental phases of the external morphology from fry to adult of a few carps of Bengal.

H. K. Mookerjee, Calcutta.

The following brief points are given for each of the following species:—

(1) *Labeo rohita.*—The fry differ from adult in having three small spots in the caudal region which, in course of development, turn into one and ultimately disappear in adults.

(2) *Labeo calbasu.*—The fry differ in colour, in having yellow bands at the nape, a yellowish spot at the insertion of the dorsal fin and yellow colour sometimes alternating with black of the body. In adult the colour of the body is completely black.

(3) *Labeo bata.*—The fry differ from the adult in having a spot on the 5th and 6th scales on the row of scales just above the lateral line. This spot fades with age.

(4) *Labeo gonius.*—The fry differ in colour and have white groove-like lines parallel to the lateral line.

(5) *Barbus sarana.*—The fry differ from the adult in having a linear band on the back below the insertion of the dorsal fin, which gradually becomes round and ultimately disappears in the adult.

(6) *Catla catla.*—In the fry the red tinge of the gills filters out through the transparent operculum, which does not happen in the adult.

(7) *Cirrhina reba.*—The fry differ from the adult in the presence of three spots in the caudal region which ultimately unite with a blue-black line along the lateral line in the adult.

(8) *Cirrhina mrigala.*—The fry differ from the adult in colour. The colour along the lateral line of the fry is bluish-green while that of the adult is silvery dark grey.

14. Observations on the breeding and development of *Gambusia affinis* (Baird and Girard) in Indian waters.

K. Gopinath, Trivandrum.

Observations were conducted on fish reared in table aquaria in the laboratory which were supplemented by observations at one of the *Gambusia* hatchery ponds at Neyyattinkara, Travancore. The temperature in the aquaria ranged from 77–88°F. during the period of observation.

The breeding season of this fish in this part commences in April and extends to October, the maximum production occurring in June at a mean temperature of 84°F. Broods are normally formed at intervals of 35 days, though in the warmer months the intervals tend to be shorter.

Fertility depends on the age of the fish. One specimen of two and a half months old produced five young ones at the time of the first brood, sixteen at the second brood and thirty-five at the third. This is the maximum number so far recorded.

Broods are usually thrown off during the early morning hours and a fresh born young measures about 8 mm. and is an exact miniature of

the adult. Sexual differentiation becomes apparent fifty days after birth, while the actual elongation of the organ becomes distinct only sixteen days later. The organ takes one month to complete its development. The rate of growth differs in the male and the female.

15. On two types of Horse-Mackerel eggs found in the plankton from the sea opposite West Hill (Malabar).

K. CHIDAMBARAM, West Hill (Madras).

The identity of two kinds of Horse-Mackerel eggs, namely, those of *Caranx kurra* and *C. kalla* was determined. The eggs are small being only 0·63 mm. and 0·56 mm. respectively in diameter with one exceptionally large oil-globule. In the larva of *C. kurra*, the trunk is ·7 mm. long and the tail is ·5 mm. long while in that of *C. kalla* the trunk and tail each measure ·5 mm. The total number of myotomes in the larvae of both the species is only 24. Their distribution in *C. kurra* is 7 in front of and 17 behind the anus whereas in *C. kalla* there are 9 and 15. In both cases, the tail is twice as long as the trunk. Migration of the myotomes in the region of the anus either forwards or backwards was not noticed during the period of observation.

16. Fishes of Ghanpoor Anicut.

M. RAHIMULLAH, Hyderabad (Deccan).

A report on the fish survey of the anicut and Mahboob canal is given. The distribution of the fish fry by the agency of the canal has been fully dealt with. Some important fishes are mentioned and their breeding habits discussed to some extent. It is concluded that the anicuts, instead of being any barrier to the migration of fishes, are really helpful in a sense that they provide shelter and breeding places for fishes.

17. Contrivances used for catching fish in Hyderabad, Deccan.

M. RAHIMULLAH, Hyderabad (Deccan).

Cast-net, stake-net, gill-net and other nets commonly used for catching fish are described, and some special ones for catching particular types of fishes are also dealt with.

Some other contrivances besides the nets are also explained.

18. The fisheries of the Vishvamitri (Baroda)--A preliminary report.

S. T. MOSES, Baroda.

In this preliminary report the author mentions the geographical and other features of the Vishvamitri and briefly describes the fishery of this river. A list of 33 species of fish collected as a result of the fishery survey in 1941-42 is included.

19. A preliminary account of the fish larvae from Bombay Harbour.

D. V. BAL, Bombay.

Plankton samples were collected with a tow-net at the surface from Bombay Harbour for some months past. The fish eggs and larvae contained in them tend to show that the main spawning season of some of the fishes of Bombay is during the monsoon, particularly in July and August.

The fish larvae from the catch are being thoroughly studied and so far four species of larvae have been related to their adults. Results of these observations are given in the paper.

20. Sexual dimorphism in *Schizothorax longipinnis* Heckel.

NAZIR AHMAD, Lahore.

In a paper by the present author, read before the meeting of the Indian Science Congress, 1941, sexual dimorphism in a Schizothorax fish was described. He has now found similar external characters distinguishing the male from the female in *Schizothorax longipinnis* Heckel.

In the present paper the author gives systematic account of *S. longipinnis* and also a short summary of work on sexual dimorphism in some Indian freshwater fishes.

21. Observations on the ecology and fish-fauna round about Hanumkonda (Hyderabad State).

B. K. DAS, Hyderabad-Deccan.

Three large tanks, viz. Waddapalli, Gopalpur and Dharmasagar, situated round about Hanumkonda (suburb about 91 miles north-east of Hyderabad) have been investigated.

The topography and ecology of the three tanks is described in detail.

The fishes were caught with the help of about 6–16 fishermen who used large circular cast-nets. The method of using these nets is described in the paper and the species of fish collected in the three tanks are listed.

The paper will be illustrated with lantern slides and plates.

Amphibia

22. The chondrocranium of *Tylototriton verrucosus* Anders (Urodela).

L. S. RAMASWAMI, Mysore.

A study of the fully formed chondrocranium of *Tylototriton* larva (t. 1·48 mm.) was made and in this connection the adult heads of *Tylototriton*, *Triturus*, and *Salamandra* were also studied. Like *Triturus* and *Salamandra* the chondrocranium exhibits the fused ascending, otic and basal connections. The otic capsule has grown forwards and there is a pre-facial commissure as in *Ambystoma*, etc. In *Triturus* there is a discontinuity between the otic process and otic capsule in adult though the otic process abuts intimately on the ossified cartilaginous portion of the otic capsule. The author has been able to confirm the observation of Stohr that the basal and basitrabecular connection is permanent.

23. The anatomy of the duodenal region of some Apoda (Amphibia).

L. S. RAMASWAMI, Mysore.

An examination of the gall bladder and pancreas was made in *Ichthyophis glutinosus*, *I. monochrous*, *Uraeotyphlus narayani*, *Gegenophis carnosus*, *Scolecomorphus uluguruensis*, *Herepele ochroeephala*, *Dermophis gregorii*, *Boulengerula boulengeri* with a view to noting the openings of the duct into the intestine. It is noticed that the pancreas opens into the intestine by two or three independent ducts, two (or one when there are only two ducts) of which are anterior to the opening of the choledochal duct, the other being posterior. This condition simulates the one noticed in Urodela and differs from Anura. The gall bladder is also merely an enlargement of the hepatic duct as in Urodela and does not have two cystic ducts as in frog.

24. A comparative account of the vascular arches and heart in some Apoda (Amphibia).

L. S. Ramaswami, Mysore.

Foreign apodan genera like *Scolecomorphus*, *Herpele*, *Dermophis* and *Boulengerula* were studied, with a view to compare the vascular systems with the South Indian forms like *Uraeotyphlus*, *Gegenophis* and *Ichthyophis*. In *Gegenophis* there arise from the truncus two systemico-carotid arches (the left being thinner) and only a single right pulmonary artery, while in *Ichthyophis* and *Uraeotyphlus* the pulmonary arteries are double. In *Herpele* there is a single right systemic arch arising from the truncus on its right and runs caudally and before joining the lateral dorsal aorta coming from the right carotid gives off a small pulmonary artery to the lung. *Ichthyophis*, *Siphonops*, *Uraeotyphlus*, *Dermophis*, *Boulengerula* and *Scolecomorphus* are closely related. Two systemico-carotids and two pulmonary arteries arise from the truncus. The conus carries either one (*Scolecomorphus*, *Herpele*, *Boulengerula*, *Siphonops*, *Chthonerpeton*, *Gegenophis*) or two rows of valves (*Ichthyophis*, *Hypogeophis*, *Dermophis*). The atrium in the possession of a fenestrated septum resembles the same in Urodela.

25. *Gegenophis carnosus* from South India.

B. R. Seshachar, Bangalore.

All accounts of *Gegenophis* are based on the original description of this form by Beddome (1870) who collected two specimens from Wynaad. This genus is found only in India and is represented by a single species (*Gegenophis carnosus* Bedd.). A recent collection of a large number of specimens shows that Beddome's description is not quite accurate. In the matter of size, the number of folds on the body, in coloration and in the mode of occurrence, my findings are at variance with those of Beddome. It is probable that Beddome's specimens were juvenile. Further, Beddome's descriptions would seem to suggest that *Gegenophis* is only a cryptic form. I have found the animal an actual burrower, never having seen it, like *Ichthyophis*, leading a surface cryptic existence. A full description of the species is given in the paper.

Reptilia

26. The chondrocranium of *Calotes versicolor* Daud.

L. S. Ramaswami, Mysore.

The chondrocranium of *Calotes versicolor* was examined with the aid of wax models. The cartilaginous skull of a 8 mm. embryo discloses that the trabecula communis extends anteriorly ventrally to the continuous nasal and interorbital septum. The nasal septum is not fenestrated unlike what is described in *Lacerta*. The parieto tectal cartilage is also a dorsal extension of the septum nasi. In *Lacerta* the cavum concha is closed on all sides by cartilage and opens anteriorly by aditus concha; in *Calotes* the lateral nasal glands are not enclosed in a cavum since it is not surrounded by cartilage. A lamin. orbitonasalis was not noticed. The processus ascendens has no connection with the quadrate or with pila antotica. Generally connected with the meniscus pterygoideus cartilage (basal process), the ascendens cartilage articulates with the basi-trabecular process. In the stage of *Calotes* examined the pterygoid bone is formed and the basal process is a flat piece of cartilage articulating with an equally flat basi-pterygoid process. The processus ascendens and meniscus pterygoideus are separated by the pterygoid ossification.

27. A method of distinguishing the different species of snakes, poisonous as well as non-poisonous, based on a study of the external appearances of the species found in Hyderabad-Deccan.

FAZLE KARIM KHAN, Hyderabad-Deccan.

India loses 100 human lives every day, due to snake-bite, besides the loss in cattle, etc.

Fifty per cent of these fatalities are due to shock only. The remaining 50% are due to the effect of the different venoms.

To reduce the first 50% mortalities, the public should be able to distinguish poisonous from non-poisonous snakes. To attain this object, the only practical guide has so far been the arrangement of scales on the body of the snake. In this paper, the author points out that the scale-arrangement fails to be of help under certain conditions, and suggests that the configuration of the body and the pattern of the external colour-markings should be taken as guides for the recognition of a snake.

To prove his claim, he will exhibit actual preserved specimens of the common species of his place, pictures of these in natural colours and natural sizes, and cards carrying a short description of each species.

28. Observations on the development of the brackish water snake *Cerberus rhynchops* (Schnieder).

K. N. PARAMESWARAN, Madras.

Previous work has established the occurrence of allantoic placenta in the sea-snakes *Enhydrina schistosa* and *Hydrophis cyanocinctus*. If the sea-snakes have acquired their aquatic habits secondarily, then forms living in brackish water may be expected to show viviparity and possibly a placental condition. *Cerberus rhynchops*, a thoroughly brackish water snake, has been investigated and reveals a viviparous condition and assumption of allantoic placenta. A complete series of the stages of development has been collected and full details are given in the paper.

Cytology

29. The cytoplasmic inclusions and the secretory activity in the cells of the hepatic caeca of *Periplaneta americana*.

D. R. BHATTACHARYA *and* MURLI DHAR LAL SRIVASTAVA, Allahabad.

The Golgi apparatus appears in the form of strongly osmiophil discrete dictyosomes, or networks composed of these. On staining the cells with a dilute solution of neutral red no cytoplasmic elements even distantly simulating the dictyosomes, discrete or aggregated in a network, appear. The secretory granules, which are observable even without using the stain, take a deep tinge within 10 to 15 minutes of the immersion of the cells in the dye. The morphology of mitochondria is strikingly different from that of the Golgi apparatus and there can be hardly any doubt that the two are independent constituents of the cell. The rôle of the cytoplasmic inclusions in the secretory activity of the cell is discussed.

30. Supra-vital experiments on the spermatocytes of *Vaginula*.

R. S. DAS *and* D. R. BHATTACHARYA, Allahabad.

The most remarkable feature of the spermatocytes of *Vaginula* is the clearness with which the Golgi apparatus can be observed without the application of any dye. The Golgi apparatus which is composed of

a typical osmiophil cortex, and an osmiophobic portion, does not stain with neutral red, nor with Janus Green B, although it is easily fixed and stained by F.W.A., followed by iron alum haematoxylin. In addition to the Golgi apparatus there are numerous small mitochondrial elements which are fuchsinophil and are stainable with Janus Green B. It is submitted that the Golgi apparatus is not the 'chondriome actif' of Parat.

31. Spermatogenesis of the dog-tick, *Rhipicephalus sanguineus* (Latreille).

GANAPATI PRASHAD SHARMA, Lahore.

In a paper by the present author read before the meeting of the Indian Science Congress, 1941, the spermatogenesis in the cattle-tick, *Hyalomma aegyptium* was described. In continuation of that the present work was undertaken. Ticks were collected from street dogs in Lahore and Ambala.

Spermatogonia, spermatocytes and early spermatids are characterized by the presence of thick striated limiting membranes round them. The mitochondria exist as pale fine granules in the cytoplasm. The Golgi elements, in the form of rings and crescents, are also found abundantly.

A study of spermateliosis has revealed the presence of two types of sperms, one normal eupyrene and another abnormal apyrene. The former is formed by the usual elongation of the spermatid, but still it is atypical as the head of the sperm is curved backwards. The latter is formed by a peculiar process of invagination during which the head of the sperm is dropped off as a whole.

32. Spermatogenesis of *Daphnia pulex* (De Geer).

RAJ KUMAR JAIN, Lahore.

The amoeboid sperm of *Polyphemus* (Zacharias) aroused interest in the study of sperm and spermatogenesis of *Daphnia pleux*. The cellular elements in the testis are of small size, and, therefore, not favourable for a detailed study.

In the spermatid the nucleus, at first vesicular, becomes condensed to form a small sphere. The Golgi bodies and the centrioles could not be discerned, and apparently are absent. The mitochondria are fine pale granules, difficult to demonstrate.

During spermateleosis, the nucleus begins to elongate, the cytoplasm forming a thin envelope. The mature sperm is rod-like and not amoeboid as in *Polyphemus* and many other Cladocera. The acrosome is absent.

33. The so-called nucleolar extrusions in Piscine ova.

ABU BAKR, Lahore.

The work was carried out on fourteen different species caught from Lahore. The behaviour of the germinal visicle has been studied and the previous work discussed. It has been demonstrated that the so-called nucleolar extrusions described by some of the previous workers are a myth. The work of J. T. Cunningham (1898) denying the existence of nucleolar extrusions in certain marine fishes has been fully confirmed by my studies.

General

34. The fish-louse, *Argulus foliaceous* Linnaeus, causing heavy mortality among carp fisheries of Bengal.

SUNDER LAL HORA, Calcutta.

During the last few months several instances of fish epidemics caused by this Crustacean parasite were reported to the writer from different

parts of the province. Some of these cases were investigated in the field, and remedial measures suggested.

In the Churchuria Fishery, Dhapa a heavy infestation of the parasite was observed in July on *Labeo rohita* (Ham.), *Catla catla* (Ham.) and *Cirrhina mrigala* (Ham.). Besides fish-lice, the gills were heavily infected with Myxosporidian parasites, mostly *Thelohanellus rohitae* (Southwell and Prashad). In the neighbouring Hanakhali Fishery, which contains slightly brackish water, the fish were absolutely healthy. A considerable amount of brackish water was introduced into the Churchuria Fishery from the Hanakhali Fishery with the result that the epidemic was checked and the fish showed no traces of parasites.

The owner of another fishery in this area reported that he usually controlled the epidemics of *Argulus* by letting into his fishery somewhat larger quantities of sewage water. This report is under investigation.

Reference is made in the paper to several other cases reported from Bengal and other parts of India.

35. Observations on the presence of digestive enzymes in the pyloric caeca of *Ophicephalus striatus* and *O. punctatus*.

A. K. DAS *and* M. RAHIMULLAH, Hyderabad-Deccan.

While working on the food of certain fresh-water fishes an attempt was made to study the digestive enzymes in the pyloric caeca of these fishes.

Details of experiments have been given and it has been demonstrated that diastase, maltase, lipase, pepsin, trypsin and bile are present. The authors come to the conclusion that the pyloric caeca in these fishes perform digestive and absorptive functions but secretory function is doubtful.

36. On the fluctuation of a few typical items of planktonic organisms in the sea opposite West Hill for the last Quinquennium (1936-37 to 1940-41).

D. W. DEVANESEN *and* K. CHIDAMBARAM, West Hill (Madras).

The following items were selected for the study: *Noctiluca*, copepods, *Evadne*, *Leucifer*, larval bivalves, arrow-worms, *Coscinodiscus*, *Fragillaria*, *Chaetoceras*, *Biddulphia*, *Pleurosigma* and *Rhizosolenia*. Because copepods and *Coscinodiscus* both maintain a high level and within this level their continuous occurrence fluctuates, they form the mainstay of the food of certain plankton-feeding fishes such as the Oil-Sardine and the Mackerel. The occurrence of *Evadne* is not only not regular but its population also occupies a low level usually not advancing beyond the 'Plenty' stage. *Leucifer* being of a comparatively large size, its food-value is higher; but its fluctuations are not remarkable; it keeps mostly to the levels of 'Few' and 'Common' stages. The larval bivalves, a favourite item of food, fluctuate between 'Plenty' and 'Few' stages. Arrow-worms also occupy the level between 'Few' and 'Plenty' stages but their rise seems to be mostly bimonthly. July, August and September are the months in which the inedible *Noctiluca* predominates, but its occurrence is fitful and discontinuous.

37. Preliminary observations on the survival of *Anopheles fluviatilis* (listonii) under controlled conditions of temperature and humidity.

RAJINDAR PAL, Lahore.

The technique followed was the same as described in my previous papers dealing with the longevity of *Anopheles culicifacies*.

It was observed that at 100% relative humidity the female mosquitoes did not survive for more than 1 hour and 43 minutes when exposed to 50°C. and 19 hours when exposed to 40°C. Females lived for 10 days at 35°C. and 18 days at 30°C. when the relative humidity was 80%. Humidities near saturation are harmful as the females did not survive for more than four days at 30°C. when the relative humidity was 100%. At very low temperatures such as 18·3°C. and 12·7°C. females survived from 50 to 63 days. Further experiments are being conducted.

Platyhelminthes

38. The morphology and systematic position of *Indocreadium*, a new genus of the family Allocreadiidae.

H. D. Srivastava, Izatnagar.

In the course of a survey of the trematode parasites of marine food-fishes at Karachi, the author found an interesting form which is described in this paper. Though obviously belonging to the subfamily Allocreadiinae the morphological peculiarities of this worm are such that it cannot be assigned to any of the known genera and, therefore, a new genus—*Indocreadium*, with *I. longicirrus* as its type—is proposed for its reception. The generic peculiarities of this parasite are the shape and size of the cirrus sac which is a much elongated bulb-shaped structure extending from the base of the oesophagus to the level of the vitellaria, the position of genital pore at the base of the oesophagus and the location of the acetabulum on a dome-shaped peduncle.

39. A review of the trematode genus *Opechona* of the family Allocreadiidae, with a description of some new forms from Indian hosts.

H. D. Srivastava, Izatnagar.

The first representative of this genus was described by Molin in 1859 as *Distomum bacillare*. Nine years later Olsson described, without reference to Molin's work, a similar form under the name *D. incresens*. The position of these two forms remained obscure for thirty-six years, till Odhner pointed out in 1904 that they were synonymous. Lebour, 1908, gave the first complete account of it but she, mislead by its incomplete account given by Molin, regarded it as the type of a new genus and named it as *Pharyngora retractilis*. She assigned the new parasite to the subfamily Lepocreadiinae, where it has been retained ever since. In 1934, Ward and Fillingham described a new trematode, related to *P. bacillare*, and pointed out the untenability of the generic name *Pharyngora* as against *Opechona* Looss, 1907. Under the latter genus about a dozen closely related species have previously been described. In this paper the author gives an account of three more members of the genus and discusses the validity of all the known species.

40. A review of the trematode genus *Plagioporus* of the family Allocreadiidae, with a description of some new forms from Indian hosts.

H. D. Srivastava, Izatnagar.

The trematode genus *Plagioporus* was created by Stafford in 1904 and now comprises a large number of species, including several of

doubtful taxonomic validity. Nicoll in 1909 created the genus *Lebouria*, which was split by Issaitschikow in 1928 into three subgenera, *Lebouria*, *Mediantestis* and *Caudotestis*. The last-named subgenus was raised to generic rank by Yamaguti six years later. Price has established in 1934 that *Lebouria* is a synonym of *Plagioporus*. Yamaguti proposed a subgenus *Paraplagioporus* under *Plagioporus* in 1939. In this paper the author gives an account of three new parasites collected from Indian hosts and discusses the validity of all the species and subgenera reported under *Plagioporus*. A key for the identification of the valid species of the genus is also given.

41. Studies on two representatives of the monogenetic trematodes genus *Polystomoides* Ward (Family Polystomatidae) occurring in Indian hosts.

H. D. SRIVASTAVA, Izatnagar.

In 1914 Stewart described a new species of the genus *Polystomum*, *P. kachugae*, parasitic in the urinary bladder of *Kachuga lineata* in India. This species has subsequently been transferred to the genus *Polystomoides*. It is a very common parasite and occurs over a wide range. In this paper is given a detailed description of *P. kachuge*, supplementing Stewart's account of this species, and a new species, parasitic in the mouth and oesophagus of a tortoise at Allahabad, is described. The validity of the various species so far described under this genus is also discussed and a key to the identification of the valid species is given.

42. New Amabiliid cestodes from Indian hosts of economic importance.

H. D. SRIVASTAVA, Izatnagar.

In the family Amabiliidae of Cyclophyllidean cestodes the proglottids have lateral appendages, which are very prominent in some species, vaginal pore is absent or may be replaced by the marginal, ventral or dorsal opening, near the male pore, or by an accessory canal. The family comprises three well-known genera, *Amabilia* Diamere, 1893, *Schistotaenia* Cohn, 1900, and *Tatria* Kowalewski, 1904. All the genera are parasitic in birds. Only one representative of this family has been previously reported from Ceylon and none from India. In this paper the author describes two representatives of the family which are parasitic in Indian hosts. Identification keys to the genera and species are also given in the paper.

43. On the Genitalia of *Helictometra giardi* (Moniez, 1879).

MOHAMMAD AMIN, Lahore.

The author in this paper discusses the different views held by helminthologists with regard to the genitalia of *Taenia giardi* Moniez (= *Helictometra giardi*). Rivolta (1878) and Neumann (1891) describe only a single genital pore, either to the right or to the left of every segment, while Blanchard (1891) and Moniez (1891) have observed double genital pores, in the above species. The author has, however, observed two ovaries and two vitelline glands in some of the segments of the Indian species, while the remaining segments contain only a single set of genital organs. The latter has a genital pore, to the right or to the left of every segment and exhibits an irregular alternate arrangement. Double genital

pores, as mentioned by Blanchard and Moniez, could not be detected in this species.

44. On the synonymity of the genera *Proalarioides* Yamaguti and *Travassosstomum* Bhalerao and of the species *Proalarioides tropidonotis* Vidyarthi and *Travassosstomum natritis* Bhalerao.

H. R. MEHRA, Allahabad.

On a comparison of the accounts of *Proalarioides serpentis* Yamaguti, 1933 and *Prealarioides tropidonotis* Vidyarthi, 1937, and *Travassosstomum natritis* Bhalerao, 1938, the author is convinced that they all belong to the same genus though to two different species, namely, *serpentis* Yamaguti and *tropidonotis* Vidyarthi (syn. *Travassosstomum natritis* Bhalerao). Bhalerao mentions clearly that his specimens agree with *Proalarioides* Yamaguti in several important respects, and also points out the difference on account of which he separates them in a new genus.

On a re-examination of entire mounts and sections the author confirms the observations made by Vidyarthi that a short pars prostatica surrounded by prostate gland cells marked off from the vesicula seminalis by a constriction continues into the long undulating ductus ejaculatorius. Besides, the points of agreement mentioned by Bhalerao a close resemblance is also shown in several other important features brought out by the author. Such a close resemblance in the morphology of the two forms makes it futile to separate Bhalerao's form in a separate genus, and the author, therefore, holds that *Travassosstomum natritis* Bhalerao is synonymous to *Proalarioides tropidonotis*, the latter name being accepted on the basis of priority.

The genus *Proalarioides*, consisting now of the two species *serpentis* and *tropidonotis*, belongs to the family Proterodiplostomidae. The subfamily Travassosstominae Bhalerao drops on account of the synonymy of the genus *Travassosstomum* with *Proalarioides*.

45. On certain new and already known distomes of the family *Cyathocotylidae* Poche from northern India with a discussion on the classification of the family.

H. R. MEHRA, Allahabad.

Three new species of the genus *Holostephanus* Szidat and one new species of each of the three genera *Cyathocotyle* Mühling, *Prohemistomum* Odhner and *Mesostephanus* Lutz are described and their systematic position discussed. *Cyathocotyle calvusi* Verma is assigned to the genus *Holostephanus*. The new species of *Prohemistomum* connects the genera *Prohemistomum* and *Linstowiella* Szidat and it is, therefore, proposed that the latter genus should be dropped. The author agrees with Yamaguti in dropping the genus *Cyathocotyloides* Szidat and considering it to be synonymous with *Holostephanus*. The genus *Paracyathocotyle* Szidat, is also dropped.

Gogatea serpentium (Gogate) belongs to a new variety, the characters of which are described.

The author agrees with Chatterji (1940) in dropping the genus *Szidatia* Dubois and including its species *joyeuxi* in *Gogatea* Lutz. *Mesostephanus burmanicus* Chatterji is described and is shown to belong to the genus *Gogatea*.

In the discussion on the classification it is pointed out that the division of the subfamily Prohemistominae into two subsubfamilies is untenable and unnecessary. The subfamily Szidatinae is replaced by Gogateainae nom. nov. Prosostephaninae Szidat is maintained as a

subfamily and the subsubfamily Prosostephanini Dubois is dropped. The author concludes that the family Cyathocotylidae should be divided into the subfamilies Prohemistominae Lutz, 1935, Cyathocotylinae Muhling, 1896, Prosostephaninae Szidat, 1936, Pseudhemistominae Szidat, 1936 and Gogatoainae n.sf.

46. Geographical distribution and evolution of the family Cyathocotylidae Poche.

H. R. Mehra, Allahabad.

The geographical distribution of the various genera and species of the family Cyathocotylidae is given.

The genus *Gogatea* represents the most primitive member of the family and is closely related to the family Proterodiplostomidae Dubois, 1936, of the superfamily Strigeides Dubois, 1936. The author believes that the common ancestor of the superfamilies Cyathocotylides and Strigeides was parasitic in reptiles, possessed a cirrus sac and a diplostomid type of morphology. The evolution of the latter superfamily took place by the division of the body clearly into a forebody and hind body and a loss of the cirrus sac.

The genus *Mesostephanus* has been evolved from *Gogatea*. The genus *Prohemistomum* has been evolved from *Mesostephanus* along one line of evolution and the genera *Holostephanus* and *Cyathocotyle* belonging to the subfamily Cyathocotylinae along another line. The genus *Linstowiella* has lost the cirrus sac secondarily in the family.

The subfamily Prosostephaninae Szidat, 1936, has been evolved from *Mesostephanus* along the third line of evolution. This subfamily is not so closely related to the subfamily Prohemistominae as to be retained in it, as Dubois has suggested.

The subfamily Pseudhemistominae Szidat is evolved from the subfamily Cyathocotylinae and possibly from its genus *Cyathocotyle*.

Chaetognatha

47. Structure of the reproductive organs of *Sagitta*.

C. C. John, Trivandrum.

The structure of the reproductive system of *Sagitta* has been described by O. Hertwig (1880), Stevens (1903 and 1905) and Burfield (1927). In 1932 the structure of *Spadella cephaloptera* was worked out by the author.

In the male reproductive organ the vas deferens is very short and the spermatozoa are liberated from the vesiculae seminalis by a rupture in its wall which heals up before the next batch of spermatozoa comes into it.

In the female the duct on the outer side of the ovary is not a double tube as was supposed by previous workers, but is definitely a single tube called the 'samentasche', which serves to receive the spermatozoa and also affords a passage for the ripe eggs to the exterior. What was supposed to be an inner tube has been shown to be only rounded masses of degenerate sperms which cling to the inner surface of the samentasche when the mucus inside the samentasche suddenly scatters as a result of bad preservation. At the time of fertilization numerous temporary openings are formed in the wall of the samentasche for the entry of the spermatozoa into the ovary. After fertilization the large mass of residual spermatozoa degenerate into rounded masses which are ultimately absorbed before a new batch of spermatozoa enters the samentasche.

Annelida

48. On the systematics of a Rhynchobdellid leech from Mysore.

L. S. Ramaswami, Mysore.

A few specimens of a rhynchobdellid leech were secured from the local tank presumably from piscine hosts. It is tentatively identified as *Placobdella ceylanica* Harding. It differs, however, from the descriptions of Harding, particularly in the disposition of the third pair of eyes. While Harding discovered the third pair of eyes on the second annulus of segment IV, it is found, in the present specimens, on the second annulus of segment V. It is intended to work out the anatomy completely.

49. A review of the mode of breeding and development in brackish and fresh water Polychaetes.

V. Runganadhan, Madras.

Brackish and fresh water Polychaetes undergo structural and developmental adaptations. The paper gives a review of these adaptations and illustrates it by tracing the life-history of *Lycastis indica*, a polychaete which lives in brackish water but can also withstand complete freshening of the water in which it lives. Full details of integumental adaptations, of the development of the egg in a cocoon, of the absence of a free swimming trochophore stage and assumption of hermaphroditic habits are given.

Insecta

50. Relation between feeding habits and feeding organs of Trichopterous Larvae.

Nazir Ahmad, Mirpurkhas (Sind).

Thirty representative species were studied resulting in establishing a positive relationship between feeding habits and feeding organs.

The mouth-parts become generally adapted to requirements of mechanical action for dealing with different sorts of food. The mandibles become less hairy, slenderer, and sharper-toothed, and maxillary palpi attain greater length and independence of movement going from vegetarian to carnivorous forms.

The fore-gut in vegetarians is quite small, being merely a broad inlet to mid-gut, but in carnivores it assumes great length and often develops a gizzard-like organ at the end of proventriculus and always carries prominent longitudinal folds in its intimal lining.

The mid-gut is quite short in carnivores being about half the length of fore-gut. Digestive processes seem quick. In vegetarians the mid-gut is longer, being 2 to 3 times the length of the fore-gut. In carnivores, ventricular epithelial cells are very tall, but in vegetarians they are squarish or of medium height. The carnivores secrete a strong pepsin in mid-gut but vegetarians produce only weak amylase and invertase in labial glands.

51. A preliminary note on the biological control of *E. amabilis* and *H. pulverea.* the two chief predators of the lac insects and lac by *M. greeni* and *M. hebetor.*

S. N. Gupta, Namkum (Ranchi).

Over 35% of the lac crop is annually destroyed by the predators *E. amabilis* and *H. pulverea.* This destruction means an annual loss of over thirty lakhs of rupees at the minimum to lac cultivators. Biological control of these enemies seems necessary as the artificial and cultural

controls can be applied only at the time of crop maturity and not during the progress of the crop. Experiments were carried out by using *M. greeni* to control *E. amabilis* of which it is a natural parasite and *M. hebetor* to control both *E. amabilis* and *H. pulverea*. *M. hebetor* is not a natural parasite of either of the predators but an introduced and, therefore, exotic parasite. The experimental data for three crops indicate that *M. greeni* is effective in controlling *E. amabilis* but to what extent it will be economically effective remains to be found out by repeated trials for some years more. Practically speaking, *M. hebetor* does not seem to go in for *E. amabilis* in the field, but it does parasitize *H. pulverea* to some extent. This braconid, however, will have to be introduced in very large numbers before any definite statement can be made either for or against its usefulness.

52. On a comparison of the life-history of *Drosicha stebbengi* Gr. with that of *Drosichiella tamarindus* Gr. (Coccidae-Homoptera), with a note on the distribution of the monophlebinae of the Indian region.

S. R. MOHAN RAO, Mukteswar.

The life-history of *D. stebbengi* as observed in Pusa and Lucknow is not materially different from what Stebbing described from Dehra Dun. Emergence of the first instar larvae takes place in November-December and copulation between the sexes is observed in March-April. The females retire under the debris for oviposition from May onwards till the end of June. Oviposition takes place immediately afterwards. The egg stage is passed through the hotter months of the year. The number of instars in the female and male is four and five respectively. The emergence of the first instar of *Droschiella tamarindus* and *D. quadricaudatus* larvae takes place in April and May and copulation is observed in June-July. The females retire under the debris from July onwards till the end of August. Oviposition follows after four months. The egg stage is passed through the colder months of the year unlike *D. stebbengi*. The duration of the egg stage is six months in both the genera of Monophlebinae. The number of antennal joints, instars and broods in both the species is given.

53. A preliminary list of coccids found on sugarcane in India.

S. RAM MOHAN RAO, Mukteswar.

Sixteen species of coccids have been recorded in this paper of which some are new to science and some are noted for the first time from this region.

54. Description of two new and redescription of a third species of *Apanteles* (Braconidae) from India.

K. B. LAL, Cawnpore.

Two new species of *Apanteles* (Braconidae) are described. The first species was reared from the caterpillars of *Sylepta balteatae* Fabr. at Pusa, Bihar, and comes nearest to *A. hyblae* Wilk., though it also differs from the latter in certain important respects. The second species was reared from the caterpillars of *S. lunalis* Guen. also at Pusa, Bihar, and in some respects resembles *A. calcycinae* Wilk. The names and full descriptions of the new species are given in the paper.

A detailed redescription of *A. chilocida* Viereck is also given on the lines adopted by Wilkinson in describing species of *Apanteles*. The specimens on which the redescription is based, were reared from the larvae of *Perigea capensis* at Nagpur and Seoni in the Central Provinces. A few others also identified as *A. chilocida* were reared in Burma. The host of *A. chilocida* was stated by Viereck to be '*Chilo simplex*' and the type

locality Japan. The present species is recorded from the Indian region for the first time and from different host.

55. A nettle grub pest of the banana plant in South India (Miresa sp.).

T. V. RAMAKRISHNA AYYAR, Hyderabad-Deccan.

Along the Malabar Coast, the banana plant is grown as a perennial crop around every household and in all gardens. So far this plant has not been found to suffer seriously from any insect pests, though some forms have been noted on it from time to time. In July 1940, in his banana plantation situated in the south-eastern border of the Malabar district close to the Western Ghats, the writer noticed a caterpillar pest which appeared to be not only a new record for the banana crop but even as a form not noted before as a crop pest. The paper gives a summary of the observations of the author on the bionomics of this insect.

56. Insects associated with the lotus plant in Peninsular India.

T. V. RAMAKRISHNA AYYAR, Hyderabad-Deccan.

As far as the writer is aware there are no accounts of insects associated with the lotus plant, excepting a solitary record by Das of a species of *Aphis* from the Punjab. The writer has been noting some insects and their ways on this plant during the past two years in the Malabar district in South India and in the Deccan and this paper is a summary of the observations so far made. The paper includes notes on the following five insects noted on the plant so far.

The lotus hairy caterpillar (*Simyra conspersa* Moore) an insect, not recorded before as a pest is found defoliating the leaves fairly seriously. The tobacco caterpillar (*Prodenia litura* F.) a widely distributed polyphagous insect though noted on over twenty food plants has not been recorded from lotus so far. An aquatic caterpillar (*Nymphula affinalis* G.) is an insect just like the rice case worm with special respiratory apparatus in the larva for breathing under water and with semi-aquatic habits. The lotus thrips (a new variety of *Scirtothrips dorsalis*) is a minute yellowish insect found in hundreds on the leaf and flower stalks draining the sap and turning the plant surface sickly. The water lily aphid (*Siphocoryne nymphae* L.) is also found in swarms on the succulent parts of the leaf and flower stalks causing sap drainage and leaf curling.

57. *Elasmus brevicornis* Gahan, as an efficient factor of control of the cotton leaf roller, *Sylepta derogata* Fb. in South India.

P. N. KRISHNA AYYAR, Coimbatore.

Sylepta derogata is particularly destructive to cotton in the southern districts of the province. *Elasmus brevicornis* is a primary ectophagous larval parasite operating in the control of this pest in the height of its abundance. The adult parasite is a small dark Elasmid positively photographic, very active and somewhat rest'ess. The preferred hosts are medium sized caterpillars, and stages other than larvae are rejected. The maximum longevity of females having access to body fluids of hosts was about 20 days while those with other kinds of food were short-lived. They have a short life-cycle covering a period of 8 to 11 days according to season. The phenomena of hyperparasitism, superparasitism and, to a limited extent, also multiparasitism have been observed in association with the species, and are described in this paper. The parasite acts as one of the most efficient factors of control of this pest. Some interesting

features of the developmental stages together with the changes and significance of the cephalic skeleton and respiratory systems are presented.

58. Identity of *Microbracon brevicornis* Wesm, and *Microbracon hebetor* Say.

M. C. CHERIAN *and* V. MARGABANDHU, Coimbatore.

Microbracon brevicornis Wesm, and *Microbracon hebetor* Say are two widely known species of world-wide distribution and are parasites chiefly of Lepidoptera. The validity of these two being distinct species is doubted by some workers. In this paper the authors review the position as it stands now and present a few points on this aspect of study. In this connection the hosts and synonymy of the parasites are given. The results of the studies made at Coimbatore in this respect are given with Cushman's observations. The authors consider that in the present state of our knowledge it seems better to keep these two species separate till further light is thrown on the subject.

59. *Trichogrammatoidea nana* Zehnt (Hym. Chalcidoidea)—a new record of an egg parasite of the sugarcane borer *Argyria sticticraspis* Hmpsn. from South India.

M. C. CHERIAN *and* V. MARGABANDHU, Coimbatore.

Trichogrammatoidea nana Zehnt is a minute egg parasite originally recorded from Java. Recently it has been noted for the first time from the eggs of *Argyria sticticraspis* Hmpsn. in India. In view of its economic importance with potentialities in biological control work a connected account is given of its systematics, distribution, hosts, possibilities of breeding, etc. The total life-cycle of the parasite is 6 days. In captivity it breeds on the eggs of *Earias fabia* and *Corcyra cephalonica*.

60. The parasite complex of the castor semilooper—*Achaea janata* L.

M. C. CHERIAN *and* MUHAMMAD BASHEER, Coimbatore.

The castor semilooper—*Achaea janata*—is subject to the attack of a number of parasites. An egg and seven larval parasites are mentioned. *Trichogramma* sp., an egg parasite, is noted for the first time and notes on its life-history and habits are given. Hyperparasites of three larval parasites, viz. *Microplitis maculipennis*, *Rhogas percurrens* Lyle and *Euplectrus leucostomus*, are also mentioned.

61. A new beetle pest of sugarcane from the Punjab.

KHAN A. RAHMAN *and* DALBIR SINGH, Lyallpur.

Pentodon sp. was collected damaging sugarcane in several localities situated along the left bank of the river Beas, and in fields adjoining several hill torrents in the Hoshiarpur district.

The pest is active from April to June when, in some years, it may destroy the crop so completely as to necessitate resowing. Adults burrow in the soil and feed on the base of the young shoots about an inch or so below the ground surface. As a result of this damage the plant produces 'dead-heart' and ultimately dries up. The beetles move underground from one plant to another. The damage is comparatively much less in sandy fields and is generally heavier in clay loam soils.

The pest has been found to damage all the varieties of sugarcane with almost equal severity. The newly planted crop is damaged more than the ratoon.

Early planting of sugarcane in the middle of February has been found to keep the attack of this beetle under check. Shoots from the shallow

planted sets are comparatively less attacked. Frequent hoeing and stirring up of the soil near the base of the tender shoots lower the attack.

62. Swarming in bees and its control.

KHAN A. RAHMAN, Lyallpur.

Swarming in bees is a natural instinct but the modern bee-keeper is put to a great deal of trouble and annoyance due to it. It is possible to prevent and control swarming or at least to reduce its ill-effects to a great extent. The paper discusses the various methods of keeping the 'honey gathering instinct' in the bees dominant and avoiding the congestion caused by the surplus bees.

63. Biology and description of *Drosichiella tamarindus* (Gr.).

KHAN A. RAHMAN *and* ABDUL LATIF, Lyallpur.

The adult male and the immature stages of this insect are described here for the first time.

Unlike other species of the tribe Drosichini which breed during winter, this species breeds during summer. A female lays 91–316 eggs in an ovisac which is deposited at the base of host plants at a depth of 2" to 6". The eggs take seven months to hatch (during October–May) in the fields, whereas at 25°C. they hatch out in the first week of March. The insect passes through three nymphal instars which are completed in 40 to 65 days during May–July. Pupal stage (which is met with in males only) occupies 10 to 14 days. Male is short-lived and is met with during July. Females survive for 59 to 81 days and crawl down the host plants during August-September.

This is the first record of this insect from Northern India.

64. Is *Drosicha stebbingi* (Gr.) synonymous with *Drosicha mangiferae* (Gr.)?

KHAN A. RAHMAN *and* ABDUL LATIF, Lyallpur.

The diagnostic characters of *Drosicha stebbingi* and *Drosicha mangiferae* as described by Green (1902), Lefroy (1908), Morrison (1928) and Beeson (1941), are the presence of six and eight abdominal tassels in the adult males, and five and six jointed antennae in the first instar nymphs respectively. Researches carried out at Lyallpur have shown that (1) the fourth pair of abdominal tassel, may be altogether absent and when present its size may vary from being vestigeal to 0·45 mm. in length, (2) the two species interbreed freely in nature, the first instar nymph in each case having five jointed antenna. Moreover, the two species showed similar life-history and habits and behaviour and fed on the same food plants. Morphological studies did not bring to light any specific differences between the two species. These observations lead to the conclusion that *Drosicha mangiferae* as stated by Morrison (1928) and Beeson (1941) is not a separate species but is synonymous with *Drosicha stebbingi*.

65. Cetoniidae from the Punjab.

KHAN A. RAHMAN *and* M. A. GHANI, Lyallpur.

The beetles of this family destroy leaves and flowers of plants.

The *Fauna of British India* records 16 species of this family from the Punjab. During the last few years 12 more species have been collected and this brings up the total number of Cetoniidae from the Punjab to 28. The names of these twelve species and the localities from which they were collected are given in the paper.

SECTION OF ANTHROPOLOGY AND ARCHAEOLOGY

President :—N. P. CHAKRAVARTI, M.A., PH.D.

1. Height indices of the head of some Indian castes.

A. AIYAPPAN, Madras.

Head height is one of the characters on which are based the distinction between the northern and the southern dolichocephals of India. Hrdlička and recently Stewart have shown how the measurement of head height suffers from lack of standardization, and also how misleading the height-length and height-breadth indices of the head can be. Existing data on head height are scanty not only in India but in other parts of the world, but it would be useful if future workers bear in mind the caution given by Stewart. In the present paper Turner's and Anantanarayana Aiyer's figures for the vertical indices of the Uriya and Tamil skulls are compared to show how useless the height-length index is in comparative studies except in series having similar cranial indices. The dolichocranial Uriyas and the Tamil series of Aiyer are orthocranial, i.e. of medium head height, while the mesaticranial Uriyas and the dolichocranial Tamils of Turner's series are hypsicranial. The mean height index shows that the difference between the various Uriya groups is not pronounced, while that between the two Tamil series is real.

Extending, tentatively, the use of the mean of the length and breadth to compare the relative auricular height in the living, the mean auricular height index for a dozen selected castes was calculated. Of these the Kallars and Iluvas have been contrasted by Guha with the U.P. Brahmans, the former having among others a high cranial vault as a distinctive character. The length-height index and the mean height index of the Iluvas are as low as those of the U.P. Brahmans and the corresponding indices of the Kallars are not significantly higher. On the basis of the mean height index, among the dozen selected castes, the Nayadis, Namputiri Brahmans, Telugu Brahmans and the Chenchus have the greatest head height, while the U.P. Brahmans and the Iluvas have the least.

2. The angle of humeral torsion in the South Indian.

A. A. AYER *and* (MISS) B. UPSHON, Madras.

This angle is one of the important anthropometrical features studied in the humerus. Forty bones have been investigated, twenty right and twenty left. The standard technique described by Martin (1928) has been followed.

The mean value of the angle of humeral torsion is 152·1 for the whole series. It is 152·7 on the left side and 151·5 on the right side. The angle is 135 at birth and it gradually increases reaching the definitive size during early adult life (Martin, 1928). The angle in the South Indian—152—is approximate to that of Neolithic French, is larger than that in the Chinese—147—and is smaller than that in the recent French—164.

The significance of this slightly increased angle in the South Indian is probably to be accounted for by his retention, in this as in many other respects, of 'infantile' or 'adolescent' features.

3. The height indices of the South Indian cranium.

A. A. AYER, Madras.

Twenty skulls of adults of Hindus of the lower castes have been studied. Sixteen were of males and four were of females. Though the number studied is small, in so far as the length-breadth index closely agrees with comparable data of other workers, the sample can be regarded as a typical sample. These observations show that the lower caste South Indian cranium is long and high vaulted. The mean values of the various indices are given below in tabular form.

Name of Index.	*Mean value.* Males.	Females.	Males plus females.
Length-breadth index ..	73·4	74·1	73·6
Length-auricular height index	64·8	66·4	65·1
Breadth-auricular height index	88·2	89·9	88·6
Length-basibregmatic height index	73·9	73·9	73·9
Breadth-basibregmatic height index	99·1	99·6	99·2

4. The problem of the origin of the Nordic-like and Mediterranean-like races.

A. A. AYER, Madras.

Widely distributed in the racial composition of India are Nordic-like and Mediterranean-like dolichocephalic racial groups. The possibility of the Nordic and Mediterranean races being two closely allied branches of a common ancestral stock is already recognized, of which further suggestive evidence is presented here.

A study of the brain of the South Indian Mediterranean-like type reveals: (i) a relatively large ratio of brain weight to body weight, viz. 1 : 40, (ii) a large coefficient of cephalization, viz. 2·86, (iii) frequent occurrence of postorbital limbus and pretentorial limbus, and (iv) an increased general height index of the brain. The author corrolates the above features and the high vaulted cranium with a relatively large brain trying to accommodate itself in a restraining cranial cavity, and deduces that there has been a reduction of the body size of the race from an original stock of larger body size.

The suggestion is put forward that from a larger sized dolichocephalic racial stock that was the progenitor of the Nordic-like and the Mediterranean-like types of man, the former became the culminating branch, while the latter arose as a side branch. Sometime, somewhere, due to unknown genetic, dietic, hormonal or environmental factors, a part of the original stock underwent reduction in body size giving rise to the Mediterranean-like type which retained many 'adolescent features' as less stature, less robust bones, more graceful build, high vaulted cranium, increased coefficient of cephalization, less body hair, etc.

5. Modern technology of the primitive tribes of Dudhi.

BALKRISHNA SINGHANIA, Lucknow.

The introduction of new tools and implements has revolutionized the material culture of Dudhi. As a consequence, tribes are fast disappearing and are being assimilated into the lower ranks of the caste system. How far improved technology is responsible for cultural evolution in tribal areas has been discussed in detail.

6. Medicine, magic and leechcraft among the pre-Dravidian tribes of Mirzapur, United Provinces.

BALKRISHNA SINGHANIA, Lucknow.

The author discusses the interrelation between medicine, magic and leechcraft, giving first-hand data from the tribal cultures of Dudhi (Mirzapur district) in the United Provinces. He details the tribal beliefs, customs and practices of the Korwas, Bhuiyas, Agarias, Kharwars and Cheros and compares them with those obtained among the neighbouring caste people, showing what might be interpreted as the principle of graded utility.

7. Some aspects of the worship of Narayana.

NANIMADHAB CHAUDHURI, Calcutta.

An attempt is made in this paper to trace the development of the conception of Narayana and the history of his connection with Viṣṇu through the Vedic literature to the Mahabharata and the Vaiṣṇavite Puranas. The author finds from them some support for the theory that Narayana worshipped according to *Sātvata vidhi* based on *ahiṃsā* by King Vasu Uparicara and called Pāñcarātrika was the special deity of the Sātvatas, worshipped according to their own peculiar mode, which was borrowed by Uparicara. This special god of the Sātvatas or Yādavas was replaced later by Vāsudeva and his forms (vyūhas), and it is possible to trace this Pāñcarātrika Narayana, an associate of Nara and described repeatedly as an ancient ṛṣi to the Puruṣa Narayana of the Śatapatha Brāhmaṇa and to the Ṛg-Veda ṛṣi Narayana who was the author of the Puruṣa-sūkta.

An attempt is also made to trace the development of the aniconic worship of Narayana in the śālagrāma-śilā and attention is drawn to the important socio-religious function concerned to some extent with Vedic rites attributed to the śālagrāma. It is suggested that this association with the surviving Vedic rites might be due to the old Vedic trait in the worship of Narayana according to the Pañcarātra śāstra made in conformity with the four Vedas by Narayana himself. It might also be due to the new development in the conception of Narayana as a household deity of which some trace is to be found in the Ramayana and under which he is now generally represented by the śālagrāma.

8. Linga worship in the Mahabharata.

NANIMADHAB CHAUDHURI, Calcutta.

In the present investigation an attempt is made to show that the linga worship inculcated in the Mahabharata is a new composite cult, the full implications of which have been generally overlooked and that it is different from phallic worship known elsewhere. An examination of important points in the exposition of the worship of the linga given by the sage Upamanyu shows that the emblem, the worship of which is inculcated, is a synthetic symbol assimilating the symbols of Rudra and the Devi and not merely a representation of the phallus known elsewhere. So three subjects come up for examination, namely, the cult of the phallus, the cult of Rudra and the mother-goddess cult. Investigation into the cult of the phallus shows that it was of pre-Vedic and most likely of prehistoric origin in India, its existence being known to the Ṛg-Veda. Investigation into the cult of Rudra shows that from the Ṛg-Veda up to the period of the Sutra literature Rudra had nothing to do with procreation, rather he was a malevolent, destructive god. From about second century B.C., however, certain archaeological evidences (*mukhalingas*) begin to come into notice showing that Rudra was coming to be associated

with representations of the phallus. Investigation into the mother-goddess cult shows that already in some of the Brahmanas, Aranyakas and Upanisads the Devi or Uma representing the great Mother had come to be associated with Rudra as his consort. Such association in some measure may be traced also to the Ṛg-Veda. It is suggested that the association of the old Rudra cult with the cult of the Devi brought about the appropriation of the old, pre-Vedic phallic symbol by Rudra and the emergence of the new composite cult of the linga as it is expounded in the Mahabharata.

It is further suggested following up Upamanyu's story that the rise of this new composite cult should perhaps be traced to a matriarchal system of society.

9. Glimpses into India's heritage in mineralogy and mining (from the earliest times to 1200 A.D.).

S. K. Roy, Dhanbad.

The history of mineralogy and mining in India is very old. But their tradition in India has suffered to a great extent for want of proper study of old records.

The people who ruled over the whole of Northern India many thousand years ago were conversant with the use of metals, while even in the pre-historic time iron industry was very highly developed in India. Gold, silver, copper, iron, tin, lead, cornelian and agate, etc. were largely used by the people of pre-Vedic civilization who lived in the Indus Valley.

In the Ṛg-Veda, which is about 4,000 years old and which is undoubtedly the most ancient record of the Aryans, there are many passages which clearly show that the Vedic Aryans knew the use of gold, silver, iron, copper, lead, tin and bronze.

In the Ramayana and the Mahabharata which reflect the golden ages of Indo-Aryan civilization, as well as in the Puranas, we find all sorts of metals, minerals and rocks very largely used in India. Even rock crystals and mica had industrial applications at that time.

The Jatakas mention of metal coins and even gold coins in abundance. According to the Jatakas, the smiths occupied such an important position in the society that even ministers of the king are stated to have been selected from the heads of this guild.

During the historic period from about 400 B.C. we find that mineralogy and mining knowledge in India had attained a very high state of perfection. Very good proofs of this fact are obtained from the records left by Megasthenes and Arrian and also from the Arthasastra of Kautilya, the famous prime minister of Chandragupta. What an important position the mining industry occupied in the system of government developed by Chanakya, the Machiavelli of India, can be understood from the sloka occurring at the end of Book II, Chapter XII of Arthasastra. In this sloka the great scientist-diplomat says, 'From the mine originates treasury, from the treasury comes the army, the whole earth is gained by the treasury and army, and it has a treasury for its ornament.'

Chanakya mentions the existence of a director of geological survey, a chief inspector of mines and a government metallurgist in the State of his time 2,400 years ago and in the Arthasastra he clearly defines the duties of these departmental heads. In this work is described in great detail the various means of identification of the ores of gold, silver, copper, tin, lead, iron, zinc and of various gem stones, pearls and corals. The author knew how to locate a petroleum deposit and he describes a mineral oil which is an ore of gold itself, and when mixed with copper and silver, that oily substance would change these metals into gold. He also mentions about explosives, so very useful for mining operations.

The excellent mining traditions of Arthasastra continued and further advance was witnessed during the reigns of Emperor Asoka, the Kushana and the Gupta Emperors, when great chemists and physicians like

Nagarjuna, Kanada, Charaka, Susruta flourished. Minerals were used for the first time in history as medicines for internal use, and the famous iron pillar of Delhi and copper image of Buddha (80 ft. high) at Nalanda were erected. After the Gupta rule there came the ages of stagnation and deterioration and then the dark age from the point of view of scientific advancement—1200 to 1900 A.D.

SECTION OF MEDICAL AND VETERINARY SCIENCES

President :—F. C. MINETT, D.Sc., M.R.C.V.S.

Bacteriology

1. A case of acute cutaneous glanders in man.

G. PANJA *and* B. C. CHATTERJEE, Calcutta.

A case of acute cutaneous glanders in man is described. The disease is extremely rare in India and abroad. It was characterized by an eczematous lesion on the left hand, swollen and tender lymphatics on the fore-arm leading from the lesion, an abscess above the elbow and numerous flaccid large discrete pustular lesions on the face, the arms and the trunk simulating smallpox. The patient died within a short time. *Pfeifferella mallei* was isolated in pure culture from the abscess, the pustular lesions and the circulating blood. The organism was studied thoroughly by morphology, cultural characters, serological reactions and pathogenicity tests.

2. Lethal action of potassium permanganate in vibrios.

G. PANJA, Calcutta.

Potassium permanganate in a high dilution of 1 in 10^6 is bactericidal to *Vibrio cholerae* and a still higher dilution of 1 in 10^9 is lethal to non-agglutinating vibrios. The above dilution fails to kill even a lower number of *Bact. typhosum*. In presence of organic matter a lower dilution of 1 in 5,000 is necessary to kill the vibrios. Lysis is associated with destruction of vibrios especially in stronger solutions of the drug. Such a lysed preparation can be used as an effective cholera vaccine.

3. Tuberculosis in goats.

BALBIR SINGH, Nagpur.

The incidence of tuberculosis in goats was first recorded by Koch in 1884. The age-long belief in India has been that this species of animal is immune to tuberculosis and with this presumption its milk has always been advocated to be fed to human patients affected with tuberculosis. Some even regard a 'goaty' smell to be endowed with therapeutic properties.

It was only recently in 1932 that Iyer reported tuberculous infection of about 0·64% in hill goats at Mukteswar.

Out of 533 goats slaughtered for Goat Virus production at the Veterinary Laboratory, Nagpur, macroscopic tuberculous lesions were discovered in one goat only, i.e. an infection of 0·18%.

This black local bred she-goat aged about 4½ years did not show any abnormal antemortem symptom. A good thermal reaction to Goat Virus injection was produced.

Post-mortem examination revealed yellowish nodular lesions present in all the lobes of the lungs, being especially marked in the apex of the left lung. Few pearl nodules scattered on the inner lining of the left thoracic wall were also encountered.

The diagnosis of Mycobacterium tuberculosis, perhaps of the bovine origin, was confirmed by the Imperial Veterinary Research Institute, Mukteswar.

4. An investigation into river pollution as a result of increasing congregation on the banks of the rivers Jumna and Ganges at the last Allahabad Kumbh Fair.

K. N. SEGAL, Lucknow.

Samples of water were taken from the Jumna and the Ganges at points one and two miles above the confluence, at the confluence and one mile below the confluence of the rivers. Altogether 131 samples were examined between December 27, 1941 to February 6, 1942. Lactose fermentation tests were done on samples from 0·001 c.c. to 1·0 c.c. Fermenters isolated and identified. Water samples were also tested for vibrios.

The bacterial load of Jumna water for a mile above the confluence was definitely higher than that of the Ganges. Bacterial load at confluence was the highest and in combined stream below the confluence it was the same as in the Ganges.

With increasing congregation the water quality began to deteriorate in both rivers. The confluence was the earliest to be affected and the last to recover. The combined stream was badly affected for a comparatively short period. Deterioration spread slowly along the Jumna but was more persistent (probably due to stagnant water).

Vibrios (non-cholera) were isolated more often from reconfluence water than from either rivers. On the Jumna they were mostly recovered from samples near the fort where a number of drains discharge. In the Ganges the vibrios were recovered at all points. They disappeared from the water after heavy rainfall and consequent flooding of the rivers. But the bacterial load was not favourably affected till several days later.

Although vibrios were rarely recovered from drain-sullage itself, the river water collected at points near the discharge of the drains frequently yielded vibrios.

5. The action of dyes in vibrios.

G. PANJA, Calcutta.

Brilliant green (1 in 100,000) is bacteriostatic on Inaba and Ogawa sub-types of *V. cholerae*, El Tor vibrio and Basra non-agglutinating vibrio.

Crystal violet (1 in 100,000), malachite green, acriflavin, gentian violet, methyl violet, methylene blue (1 in 50,000), thionin (1 in 25,000), mercurochrome, safranin, basic fuchsin (1 in 5,000) exert the same inhibitory effect on the above vibrios. Eosin, methyl red, neutral red (1 in 5,000) do not inhibit. Red dyes are poor bacteriostatics on vibrios.

Brilliant and malachite greens (1 in 100,000) are fully bactericidal for most Inaba and Ogawa sub-types of *V. cholerae* and for large numbers of paracholera vibrios isolated from clinical cholera cases, but are harmless to non-agglutinating vibrios isolated from natural sources.

Organisms belonging to the genera—Bacterium (including Salmonella), Proteus, Pseudomonas, Staphylococcus, Streptococcus, Bacillus are unaffected.

Usually, persistence of green colour and clearing after contact with the organisms indicates sterility, and discharge of colour and presence of turbidity signify multiplication. Acriflavin, crystal violet, gentian violet (1 in 100,000) are not bactericidal for Inaba and Ogawa sub-types of vibrios.

Brilliant green, added to cholera stools in a dilution of 5,000, kills the vibrios. Thirty-five cases of cholera were treated with the dye by the

mouth. Vibrios in the stools disappeared earlier than in untreated cases but clinical improvement was not usually marked.

6. The occurrence of bovine contagious pleuro-pneumonia in Assam.

V. R. GOPALAKRISHNAN, Gauhati.

Details are given of investigation of bovine contagious pleuro-pneumonia in Assam and of the occurrence of the disease as a specific epizootic with a tendency to spread in a slow and insidious manner. Full particulars relating to the source of infection, nature of outbreak and localities affected are given.

Symptoms, course, post-mortem lesions, means of control and treatment are described. Infection is generally confined to cattle. Mortality is high, viz. 60 to 70%.

Buffaloes rarely contract the infection in the later stage of the outbreak. Goats and sheep appear resistant to natural infection.

Successful transmission experiments with fresh lung exudate have been made in healthy bulls at Gauhati. Experimental reproduction in goats was unsuccessful.

The causal organism of the disease—*Borrelomyces peripneumoniae*—has been isolated by the Imperial Veterinary Research Institute, Mukteswar, from materials sent from natural cases occurring in Assam. From field observations and laboratory findings, there is substantial evidence that the disease, as it occurs in Assam, is the classical contagious bovine pleuro-pneumonia occurring in other parts of the world.

In India, this disease appears to exist only in Assam.

7. Bacteria of the paracolon group causing acute enteritis simulating cholera.

S. K. CHATTERJEE *and* K. N. MITTER, Patna.

A gram-negative, non-motile coliform organism was isolated from the faeces of patients admitted for cholera in the Medical College Hospital, Patna. No cholera vibrio could be isolated from the stool of such patients. This organism was cultivated from 12 patients out of 69 patients admitted and differed from Bact. coli being very late lactose fermenter and certain other cultural characters. At the same time three other late lactose fermenting or non-lactose fermenting bacteria were cultivated from stool. To find out which of the four were causally related to the disease, the action of patients' serum were tested against them. Only one of the types was agglutinated. This type was not agglutinated by the serum of other patients from whom no cholera vibrio was isolated or persons from whom vibrio was isolated.

It is concluded that this strain belonging to the paracolon group of bacteria is pathogenic, and is the causal organism of acute enteritis simulating cholera.

Biochemistry

8. Absorption of calcium by normal and tuberculous subjects under different dietary conditions.

B. B. RAI *and* NARAIN DAS KEHAR, Izatnagar.

It was pointed out in a previous article (Rai and Kehar, 1942) that there was greater demineralization of serum calcium in 'active' tuberculosis. In view of the essential physiological functions of calcium in the body, an investigation was undertaken to study the absorption of dietary calcium under different dietetic conditions. It has been observed that the

absorption of calcium is increased if the food contains enough of vitamins B and C.

9. An iodimetric estimation of uric acid in poultry excreta.

S. BOSE, Izatnagar.

A simple and accurate iodimetric estimation of uric acid in poultry excreta has been developed. The principle of the method consists in precipitating uric acid from an aliquot of the lithium carbonate extract of the dried excreta, with Benedict and Hitchcock's ammoniacal silver magnesium precipitant. The precipitate is subsequently decomposed with lithium chloride in acid solution and finally titrated at pH 8·8, with standard iodine solution, using freshly prepared starch solution as indicator.

The method has been tested by recovering different quantities of added uric acid from poultry excreta. The specificity of the method has also been tested by recovering different quantities of added uric acid from true poultry faeces, uncontaminated with urine, obtained from the intestines of birds, killed for the purpose.

The low oxidation potential of the iodine-iodide system ($I_2 + 2e \rightleftarrows 2I'$) affords a great advantage in the estimation of uric acid by iodine in poultry excreta, since the non-uric acid substances with higher oxidation potential do not interfere in the titration. This is evinced from the finding that about 86% of the apparent uric acid value consists of true uric acid.

10. Anti-neuritic and anti-pellagra factors of vitamin B as a preventive for leprosy.

N. K. BASU, Delhi.

In the previous papers read before the Medical Section of the Indian Science Congress (1935 and 1938), deficiency of vitamin B_2* in the diet has been shown to be one of the causative factors for production of leprosy. Present paper brings forth further evidences in support of the original theory.

Entomology

11. On the occurrence of unusual inflammatory changes by 'Bots' (*Gastrophilus intestinalis*).

M. R. MAHAJAN, Ajmer.

In the month of October 1936, a pony admitted at the Veterinary Hospital, Hyderabad-Deccan, showed an ulcerating, angry-looking swelling, of the size of a tennis ball on the tongue, that interfered with the act of feeding. This was excised and on histopathological study at the Imperial Veterinary Research Institute, Mukteswar, showed inflammatory changes due to the invasion by first stage larvae of *Gastrophilus intestinalis*.

12. Experimental studies in rat-bite fever.

B. C. BASU, Izatnagar *and* S. SEN, Calcutta.

The course of rat-bite fever, due to *Spirillum minus*, has been studied in guinea-pigs, white mice and white rats. After different incubation periods for the different animals, the parasites appear and disappear in

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* Anti-pellagra factor.

peripheral blood several times, three relapses being observed in guinea-pigs and white mice and as many as six relapses in white rats. The disease does not seem to be a febrile one in guinea-pigs. From the period of longevity it can be said that it does not inconvenience the rats.

Culex fatigans and rat-fleas do not seem to transmit the disease, as *Sp. minus* did not appear in the salivary gland and haemocoelo of the mosquitoes and the rat-fleas and it did not survive for 24 hours in the mosquito's gut and survived up to 24 hours only in the flea's gut.

13. Fleas, rodents and pasteurellosis of animals.

G. K. MEHRA, Patna.

(1) The presence of haemorrhagic septicaemia-infected fleas was established in a locality where subsequently an outbreak of haemorrhagic septicaemia broke out.

(2) In an outbreak of haemorrhagic septicaemia amongst cattle evidence was available of heavy mortality amongst rodents in the locality. Large number of fleas were seen in the burrows of the rats.

(3) It has been found that the seasonal flare up of the disease coincides with the seasonal flush of the fleas and the breeding season of the rodents.

(4) The presence of haemorrhagic septicaemia-infected fleas in an area where mortality amongst cattle due to the disease had occurred was established.

(5) Experimental field investigations showed that the fleas act not only as the mechanical carriers of haemorrhagic septicaemia organisms but also transmit the disease through their bites.

Further experimental investigations are being carried out.

The so-called predisposing causes of haemorrhagic septicaemia are briefly discussed in the light of Applied Entomology and it is shown how closely they reconcile with the view that rodents and fleas play a very important part in the transmission of the disease.

14. The control of the fowl tick (*Argas persicus* Oken) in its larval stage.

S. K. SEN, Mukteswar.

The paper embodies the results of experiments carried out with three insecticides in combating the larvae of *Argas persicus* in their parasitic stage. These were crude oil emulsion, 'Pyrocide 20' in combination with pine oil and high speed Diesel oil, and aqueous suspension of derris powder in different concentrations. The results of the earlier trials were inconclusive, reinfestation having apparently occurred in some of the fowls within 24 hours of treatment, but nevertheless, sufficient evidence was obtained to show that crude oil emulsion was inferior to the other two. The tickicidal value of a 10% aqueous suspension of derris powder was later tested on a total of about 75 infested fowls and in each case the bird was found to be free from living larval ticks when it was examined 24 hours after treatment.

15. Preliminary observations on the bionomics of *Hunterellus hookeri* How (Hymenoptera), an insect parasite of tick together with a note on its distribution.

S. RAM MOHAN RAO, Mukteswar.

The bionomics of *Hunterellus hookeri*, a chalcidoid parasite of tick is being studied with a view to utilize this insect in the biological control of ticks in India. The parasite was collected by the writer during his recent tour of the Bombay Province. When about to emerge *H. hookeri* cuts a round hole at the posterior end of the nymphal tick through which the

adult escapes. Copulation is observed to take place immediately after emergence from the tick. Parasitized nymphs were discovered in the cracks and crevices of cattle sheds. The first external indication of parasitism is swelling, irregular striping or moulting which is obviously due to the dark-coloured parasite grubs that have fed on the tissues of the host. The posterior ends of the pupae are seen to be embedded in the mass of wet faecal matter. Variation in the size of the adult parasites is observed. The number of parasites that emerged varied from 10 to 43 and the ratio of males to females was 1 to 6. This parasite is found in France, Indo-China, Cuba, Brazil, South Africa, Nigeria, South-West Africa and the United States. Five different genera of ticks are attacked by this parasite. In India it has been found to be parasitic on *Hyaloma aegyptium*, *Haemaphysalis bispinosa* and *Rhipicephalus sanguineus*.

16. Further observations on the bionomics of the goat warble-fly *Hypoderma crossii* Patton.

B. N. SONI, Mukteswar.

The goat warble-fly *Hypoderma crossii* is a serious pest of goats in North-Western India and causes considerable damage to the goat-skins produced in this country. Even, 80% of the skins may be warble-affected during the worst part of the season. The Hides Cess Enquiry Committee (1930) has estimated the damage due to various defects in goat-skins including warble holes at Rs.45,00,000 per annum.

H. crossii possesses three larval instars and experiments conducted at Mukteswar have shown that under field conditions the pre-pupal period varies from 2 to 4½ days and the pupal period extends over 58 to 64 days, against a pupal period of 32 to 38 days at a soil-moisture of 2 to 5% and temperature of 22°C. Eggs of *H. crossii* were encountered for the first time in the course of a recent survey in the Punjab and Kulu valley. They were attached in rows to the hairs on the back of goats of the Barbary breed. Unlike the eggs of *H. lineatum* and *H. bovis* the eggs of *H. crossii* are devoid of a petiole or stalk between the clasp and the egg proper.

Helminthology

17. The cercarial fauna of the irrigated tract of the Nizam's Dominions, with suggestions regarding their relationship to the trematodes parasitic in man, domestic and other animals.

G. D. BHALERAO, Izatnagar.

The paper deals with five species of Furcocercous, three of Xiphidio, two of Amphistome, three of Echinostome, one of Distome, two of Monostome, and one of Cystocercous cercariae. In each case the intensity of infection is given and suggestions are offered concerning the adult trematode parasite. The majority of the cercariae dealt with are likely to be the developmental stages of the flukes of domestic animals and a few of them of man. Adults of some of the cercariae may be found in wild animals. Three cases of double infection of molluscs are recorded.

Nutritional Diseases

18. Fluorine intoxication of farm animals. I. Blood and bone composition in fluorosis.

B. N. MAJUMDAR, S. N. RAY *and* K. C. SEN, Izatnagar.

The fluorine content of the bones and teeth of normal animals increases with age but the blood values remain normal.

Sodium fluoride fed at the level of 3·4 mg. of fluorine per kg. body weight produced symptoms similar to those reported in cattle and buffaloes from Madras, etc. Those diseases were provisionally called 'rheumatic arthritis' or 'osteomalacia', but are now seen to be cases of fluorosis. The chief symptoms were loss in weight, difficulty of movement, deformed hoof, exostoses on the long bones, debility and death. Feeding fluorine at one-tenth of the level mentioned produced no symptoms.

The administration of calcium salts mitigated the symptoms.

Blood analyses revealed little or no change in the Ca, P and Mg content. Animals on high fluorine ration showed four-fold increase in the blood fluorine concentration. Animals receiving calcium exhibited blood fluorine values intermediate between control and high fluorine animals.

Analyses of bones and teeth showed high fluorine figures in the high fluorine group of animals. The Ca and P values were almost normal. Teeth received from field cases of 'rheumatic arthritis' and 'osteomalacia' showed high fluorine contents similar to those found in the experimental high fluorine group.

The experimental findings and the distribution of fluorosis in India are included.

19. Fluorine intoxication of farm animals. II. Effect of fluorosis on the metabolism of proteins and minerals.

B. N. Majumdar, S. N. Ray *and* K. C. Sen, Izatnagar.

Administration to hill bulls of amounts of fluorine, low enough to obviate pathological symptoms, caused better retention of calcium, phosphorus, magnesium. Total food intake was greater, live weight increase was more rapid, giving better conservation of nitrogen. Most of the fluorine was retained.

Administration of high amounts of fluorine caused after six months pathological symptoms, viz. stiff gait, lameness, loss of weight, anorexia. Urinary output was increased and faecal matter was reduced. Ca and P outputs were increased but the negative balance of these minerals could not explain the symptoms. Ethereal sulphate and neutral sulphur excretions were enhanced. Urinary excretion of hippuric acid was reduced and of insoluble ash greatly increased. Loss in body weight was accompanied by a large negative nitrogen balance. Fluorine retention was highly positive, leading to deposition in bones and teeth. Addition of calcium as carbonate or phosphate to the diet of the animals of the second group improved condition, this being also shown in metabolism trials. The only significant differences, however, were a high positive calcium balance and a still greater fluorine retention, explainable by deposition of a fluoro-apatite layer over the original bone.

Physiology

20. A study of the seasonal variation of the blood constituents of normal cattle.

A. K. Pal, D. N. Mullick *and* S. A. Momin, Izatnagar.

In view of the wide variation of temperature from the summer to the winter, an investigation was undertaken to study in this region, the blood composition of the cattle at different periods of the year. Twelve healthy adult cows of age from 5 to 10 years were selected for this investigation. Blood was examined once a month for: red blood corpuscles, white blood corpuscles, cell volume, haemoglobin, iron, calcium, magnesium, phosphorus, protein, non-protein nitrogen, sugar and cholesterol. Standard methods were employed.

There were some changes in the cell volume and haemoglobin during the period of investigation. They showed higher values in winter months than in summer. Other constituents showed little variation.

21. Investigations on famine rations.

NARAIN DAS KEHAR, Izatnagar.

In view of the insufficiency of feeding stuffs for livestock during normal times (Wright, 1937) and scarcity during famine periods, an attempt is made to explore little known sources of fodder which after mixing with suitable supplements will allow the animals to tide over the lean period. The first experiment presents observations on Munj (*Saccharum Munja* Roxb.) and molasses fed to adult and growing cattle over a period of 8 and 3 months respectively.

22. Glucose-saline solution for infusion.

A. MOZUMDER, A. BOSE *and* U. P. BASU, Baranagar (Calcutta).

It is now recognized that a good substitute for blood is its serum or plasma. But none is available in quantities. Gum saline was successfully used during the last war. A demand for glucose saline is being noticed during the present crisis. In this paper the method for preparing a solution has been discussed, and it has been shown that when properly made a glucose saline solution does not give rise to any post-transfusional reaction. Special precaution should, however, be taken in selecting glucose, pyrogen free water and a good resistant glass container for making the solution and storing it for use in future.

23. Chemical investigation of hairs from the medico-legal standpoint. Part I. A study of cleansing and clearing agents for hairs and exploratory experiments for discovering a suitable chemical method for distinguishing hairs of different animals.

S. N. CHAKRAVARTI, Agra.

The examination of hairs and fibres upon weapons, in blood or other stains, upon clothing or person of the victim or assailant or at the scene of a crime is of great medico-legal importance, for by such investigations significant clues may be discovered and definite links in a chain of evidence may be established. But till now only the microscopic method is available for deciding whether a particular hair is a human hair or not. Attempts were therefore made to discover some independent method for distinguishing between hairs of different animals. Action of about thirty different reagents was tried and it was found that the action of (i) chlorosulphonic acid, (ii) nitric acid, (iii) 5% solution of potassium dichromate, and (iv) caustic alkalis is of diagnostic value. It was also discovered that the best method of bringing out the structures of the hairs for the microscopic studies is to treat the hairs either with strong nitric acid or with 5% solution of potassium dichromate. The best method for preliminary cleansing of the hairs is to treat them first with 5% potassium-cyanide solution, followed by water and alcohol-ether mixture.

24. Studies on the digestibility coefficients and biological values of the proteins in poultry feeds.

A. J. MACDONALD *and* S. BOSE, Izatnagar.

Balance studies have been carried out to determine the coefficients of digestibility and the biological values of the proteins of three experi-

mental poultry rations. The base of these rations was identical and composed of a mixture of ordinary cereals, supplemented with common salt and ground limestone. Earthnut meal, soya bean meal and separated milk were used as protein supplements and the protein contents of the final mixtures were kept constant, at 11·5%.

The digestibility coefficients of the earthnut mash, the soya mash and the basal mash plus milk were 74·82, 76·57 and 77·69 respectively, which showed that there were no significant differences in the coefficient of digestibility of the experimental rations.

The biological value of the basal mash plus milk was found to be significantly higher than that of the earthnut mash or the soya mash. The average biological value of the basal mash plus milk was 88·42 which was 40·55 and 34·77% higher than the corresponding values for the earthnut and soya mashes, respectively. The earthnut and soya mashes did not show any significant difference in their biological values.

Protozoology

25. A rapid method of staining intestinal flagellates.

H. N. RAY, Mukteswar.

Paper describes a method for staining intestinal flagellates for rapid identification—hitherto a problem of much difficulty. The method, for which the writer is indebted to Rai Bahadur Dr. G. C. Chatterjee, is briefly thus. With a long fine-bore pipette, remove the material (faecal or culture) containing the flagellates to a very small drop of dried mammalian blood on a slide. Allow the material to mix with the blood and then draw it back into the same pipette. Take a clean grease-free slide, warm gently over a flame and gently press the contents of the pipette on to the slide in long streaks. Only a small amount of fluid should be pipetted on to the slide at a time, so that the material dries up *immediately* on contact. To hasten drying, keep the slide exposed to gentle breeze from a table-fan, when warming of the slide is unnecessary. Stain with Leishman or Giemsa stain.

The method gives satisfactory preparations of cytoplasm and organelles of the flagellates but is unsuitable for cytology. The writer proposes to designate this method as 'Chatterjee's method'.

26. Incidence of malaria in Calcutta city.

S. SEN, Calcutta and B. C. BASU, Izatnagar.

The incidence of malaria cases in patients (all three species together) who attended the out-patient department of the Calcutta School of Tropical Medicine during the period of eleven years, namely, 1925 to 1935, was 2,095 of whom 778 carried gametocytes. The highest peak of malaria cases as well as gametocyte-carriers was in 1932. As to seasonal incidence, from February to July their number was at a low level and from August to January their number comparatively increased reaching the highest peak in November. On a study of the relative percentage of the three species of malaria, it was seen that *Plasmodium falciparum* was decidedly the predominating species, then came *P. vivax* and lastly *P. malariae*. From April to June *P. vivax* showed a predominating character which might account for the spring relapse of the species.

27. Malaria flocculation test.

V. S. MANGALIK *and* K. B. KUNWAR, Lucknow.

Naidu, Vasudeva Rao and Rajagopal (1942) described a modified form of sero-flocculation test for patients suffering from acute or chronic

malaria. The test was originally described by Wiesmann (1934) with distilled water. Authors claim that the test is 'a valuable adjunct in the diagnosis of malaria'. The test has been applied to large variety of cases of pyrexia, including cases of malaria showing parasites in the blood, and kala-azar and other forms of spleenomegalies. Sera from cases of pyrexia of tuberculous origin as well as from serologically positive cases of *Bact. typhosum* infection have been tested. The value of positive and negative reactions of this test are discussed in the light of our findings. The observation of the authors that 'patients with carcinoma of one or other organ have shown a positive reaction' has been reviewed.

28. Further investigations on the rôle of protozoa in activated sludge.

S. C. PILLAI, Bangalore.

Further investigation into protozoal activity in the activated sludge tank revealed the occurrence and development of several species of *Epistylis*. These form large fluffy branching colonies on the walls of the tank aeration chambers and pipes. Profuse growth of the organism is not ordinarily visible owing to agitation in the tank liquid, but can be easily seen when aeration is stopped. The organisms were inoculated into bottles containing raw or sterilized sewage, through which air was bubbled. Numerically, *Epistylis* was found to be quite twice as efficient as *Vorticella* in clotting and sludge formation, and more efficient in bringing about attendant oxidation changes.

Activated sludge from various installations invariably contains *Epistylis* sp. and *Vorticella* sp. In addition, in sludge from aeration tanks at Tuticorin (S. India), *Zoothamnium* sp. (belonging to the family *Vorticellidae*) were also found—for the first time in India. The occurrence of this organism in this particular sludge is probably traceable to the use of sea water for flushing purposes.

The peritrichous ciliate protozoa profoundly influence sludge formation in certain respects. The families *Epistylidae* and *Vorticellidae* are of greatest importance, more especially *Epistylis* sp. which thrive best, probably by natural selection, in the aeration tanks throughout the year.

Toxicology

29. *Kaner* (*Nerium odorum*) poisoning in livestock.

NARAIN DAS KEHAR *and* GOVIND RAU, Izatnagar.

The toxicity of Kaner for buffaloes, bullocks, sheep and goats has been investigated and it has been found that the plant is toxic to all stock, even if it is eaten in small quantities. The symptoms, post-mortem changes and toxic doses have been studied.

SECTION OF AGRICULTURAL SCIENCES

President :—RAO BAHADUR Y. RAMCHANDRA RAO, M.A., F.R.E.S., F.A.Sc.

Animal Nutrition

1. The chemical composition of star grass (*Cynodon plectostachyum*) and the nutritive value of mature star grass hay.

S. C. RAY *and* K. C. SEN, Izatnagar.

With progressive maturity, the percentage crude protein value of star grass showed a significant decrease, whereas after an initial fall, the ether extract value remained stationary and the total carbohydrate value progressively increased up to an age of six months. Between grass samples cut at six months age and at seven months ago, significant difference in composition was noticeable. The younger sample was definitely superior in quality. Digestibility trials conducted with mature star grass hay showed that the hay was highly palatable and the digestibility coefficient of its important constituents was also fairly high. The results of the digestibility experiment indicated that the mature star grass hay by itself might form a maintenance ration.

2. Agricultural condition as a factor in determining the quality of milk and butter from a typical dairy farm.

B. C. RAY SARKAR *and* K. C. SEN, Izatnagar.

The chemical composition of milk and butter fat and its vitamin A potency from a herd of Hariana animals belonging to a Government dairy farm have been studied. The period under investigation lasting over fifteen months included various climatic and agricultural conditions. It was noted that the vitamin A potency ran parallel to the supply of green fodder up to a certain limit which was dependent on the availability of the green feed as influenced either by the rainfall or by the irrigation facilities of the farm. From the middle of June, 1941, the potency rose to a maximum of 10,000–11,000 I.U. per lb. of butter fat, remained at that level till the end of September and then gradually fell reaching a minimum in December. It tended to rise again and attained the maximum value in February, 1942, remained stationary at that value up to the end of March and again fell till May, 1942. This variation recorded as a time-potency curve had a direct relationship with the supply of green fodder which was adequate during the monsoon period, June to September, and again during the months of February and March due to an adequate supply of cultivated fodders like berseem, oat grass, cow pea, etc. During short drought periods when cultivated fodder was not available, the vitamin A potency went down. No significant variation was observed in regard to the content of fat, total solids, solids-not-fat, total protein, ash, calcium and phosphorus in the milk, though there appeared to be a slight variation in the fat content during these fifteen months. In the case of butter, however, higher figures for iodine number, R.M. value and Polenske value were obtained during the green feeding period than during drought conditions.

3. Tree leaves as cattle fodder: Digestibility coefficient and nutritive value of some tree leaves.

CH. CHET RAM, S. C. RAY *and* K. C. SEN, Izatnagar.

The digestibility determinations of some tree leaves, namely, *Pakar* (*Ficus infectoria*), *Ber* (*Zizyphus jujuba*) and *Pipul* (*Ficus religiosa*), collected during the dry summer months of May and June, have been carried out with cattle. The digestibility coefficient of crude protein, fibre and nitrogen-free extracts is very low for *Ber*, though these leaves have been found the most palatable amongst the three tested. The digestibility coefficient of protein in *Pakar* and *Pipul* is fairly high but suffers slightly in comparison with that of cultivated fodders of similar chemical composition. Like that of *Ber*, the crude fibre and nitrogen-free extracts in *Pipul* are poorly digested.

4. The nutritive value of alkali-treated cereal straws.

K. C. SEN *and* S. C. RAY, Izatnagar.

In view of the shortage of fodder of good quality during wartime, an attempt is being made in England and elsewhere to popularize the feeding of cereal straws after treating them with dilute alkali which improves the nutritive value of the straws. In this laboratory a detailed investigation has been carried out to secure complete metabolism data regarding two of our most important cereal straws, namely, wheat and paddy straws, before and after the treatment with alkali. The results of the investigation show that the digestibility coefficient of total carbohydrates in either straw is markedly improved by the alkali treatment. This also increases the S.E. value of wheat straw from 21·3 lbs. to 34·1 lbs. and that of paddy straw from 24·4 lbs. to 35·9 lbs. per 100 lbs. of dry material. The nitrogen, calcium and phosphorus balances are considerably improved, when the animals are fed with the treated straws.

The alkali treatment appears to remove some of the factors which affect the absorption and utilization of nitrogen, calcium and phosphorus from rations containing paddy straw.

Soils, Soil Physics and Soil Chemistry

5. Influence of rainfall and altitude above sea-level on the chemical compositions of clay fractions of Indian red soils.

S. P. RAYCHAUDHURI *and* J. N. CHAKRAVORTY, Dacca.

The effects of (i) annual rainfall and (ii) altitude data on the SiO_2/Al_2O_3 ratios of the clay fractions of lateritic soil samples from twenty-two different localities of India have been estimated by evaluating the standard errors of the individual regression coefficients and applying Fisher's test. It is concluded that both (i) and (ii) possess significant negative correlation with the SiO_2/Al_2O_3 ratios of the clay fractions of these soils.

6. The function of soil cracks.

A. SREENIVASAN, Indore.

A study of the nature and extent of surface cracking during summer fallow in different fields of the same soil type reveals that cracking is extensive in fertile fields but only meagre in poor and badly drained fields. There is a significantly larger number of small cracks in the former than

in the latter. A quantitative measurement of the total surface area of cracking also shows that fertile fields crack better than poor fields. Laboratory examination of surface and subsoil samples taken from along the cracks as well as from inside the clods indicates in general that the differences in properties between corresponding crack and clod samples are less pronounced in well-drained and rich fields than in water-logged fields. In the latter case, there is greater uniformity between surface and subsoil samples taken along the cracks than from the clods.

The beneficial effect of cracking on soil properties is as good as summer cultivation with or without inversion to different depths before *Kharif* sowing.

The significance of these observations and the nature of the possible factors responsible for the degree of cracking in different fields are discussed. The need for promoting the development of soil cracks during summer fallow is also emphasized.

7. Acid character of hydrogen clays separated from a red earth from Coimbatore.*

R. P. MITRA *and* P. R. GUPTA, Calcutta.

Hydrogen clays prepared from the entire clay fraction of a red earth from Coimbatore and three subfractions of the entire clay having particle sizes ranging between specified limits have a moderately strong dibasic acid character. The coarsest subfraction resembles the entire clay in chemical composition and base exchange capacity (b.e.c.) and also makes the largest contribution towards the b.e.c. of the latter. The two fine subfractions are more or less similar to each other and have a somewhat larger b.e.c. than the entire clay and the coarsest subfraction.

8. Identification of kaolinite in subfractions of hydrogen clay prepared from a red lateritic soil by the electrochemical method.*

R. P. MITRA *and* P. R. GUPTA, Calcutta.

Hydrogen clays, prepared from two subfractions separated from the entire clay fraction of a red lateritic soil from Dacca, resemble a hydrogen kaolinite from Singbhum in chemical composition, nature of titration curve with NaOH and the base exchange capacity calculated from this curve when free inorganic oxides contained in them are removed by the method of Truog *et cl.* The similarity is very marked in the case of the finer subfraction. If the free oxides are not removed from the hydrogen clays, they materially differ from each other and from the hydrogen kaolinite.

9. Displacement of magnesium from a hydrogen clay from a non-lateritic calcareous soil from Padegaon on the addition of neutral salts.*

B. CHATTERJEE *and* P. C. GOSWAMI, Calcutta.

An agreement between the amounts of (1) *the barium adsorbed* and (2) *the acid displaced* on the addition of barium chloride to hydrogen clays is generally observed. A difference between the two quantities has been noted in the case of a hydrogen clay prepared from a non-lateritic calcareous soil from Padegaon. (1) has been found to be greater than

* This work has been carried out under a scheme of research financed by the Imperial Council of Agricultural Research, India.

(2). Further, magnesium ions along with hydrogen and aluminium ions are liberated from this hydrogen clay by barium ions. No material difference has been observed in the base exchange capacities estimated by Parker's barium acetate-ammonium chloride method before and after treatment with barium chloride. The neutral salt does not appear to bring about any decomposition of the exchange complex under the conditions of the experiment.

10. The *kari* soils of Travancore.

C. K. NARAYANAN NAIR, Trivandrum.

The *kari* soils of Travancore are a peculiar peaty type of soils, periodically inundated with saline water from the backwaters. They occupy a total area of about 30 to 40 square miles and have considerable agricultural importance in the State, the crop produced being paddy. No systematic work has so far been done to investigate into the causes of failure of crops in this area. This paper deals with results of a preliminary investigation into the probable causes of infertility of the *kari* soils. The results of mechanical analyses do not indicate any striking physical peculiarities that may explain the behaviour of these soils when under cultivation. Though the soils are rich in total nitrogen, mineralized forms of nitrogen are almost absent, thereby showing that it is not in an available form. The soils are comparatively poor in phosphates but not in potash. The organic matter content is very high and the carbon/nitrogen ratio far greater than what obtains in fertile soils. Exchangeable hydrogen, *p*H and fertility seem to have a direct relationship to the organic matter content. Fertility and salt concentration do not seem to be correlated to each other nor does salt concentration materially alter the *p*H. The buffer curves indicate a high buffer action with high organic matter content. This observation is significant and may help to explain the observed low *p*H in spite of the presence of large quantities of lime. This preliminary study points to the fact that a higher *p*H and a greater fertility can be obtained by bringing about proper conditions in the soil for the better decomposition of organic matter. Further work is in progress in the laboratory.

11. Contribution of the different size-fractions and of organic matter of some Indian soils towards their base exchange capacities.*

S. K. MUKHERJEE, Calcutta.

The base exchange capacity (b.e.c.) of the clay, clay+silt, sand and organic matter of some Indian soils has been determined by the barium acetate-ammonium chloride method of Parker. The clay, clay+silt and sand were obtained as in the mechanical analysis of soils but without pretreatment with hydrogen peroxide. The b.e.c. of each of these fractions (excepting the sand) was determined both before and after treatment with hydrogen peroxide. From the difference in b.e.c. in the two cases and the percentage loss on ignition, the b.e.c. of the organic matter was calculated. Of the different fractions, clay makes the highest contribution to the b.e.c. of the soil and then the organic matter. Though the percentage of organic matter is very small in the soils studied, its contribution is appreciable by reason of its high b.e.c. The contributions of silt and sand are quite negligible. The b.e.c. of the organic matter is of the same order as obtained by other investigators. The organic

* This work has been carried out under a scheme of research financed by the Imperial Council of Agricultural Research, India.

matter associated with the clay has a higher b.e.c. than that associated with either the silt or the entire soil.

The sum of the contributions made by the different constituents of the soil determined separately compares satisfactorily with the b.e.c. of the soil itself.

12. A comparison of different methods of estimating base exchange capacities and exchangeable hydrogen of hydrogen clays, acid soils, and partly and completely desaturated soils.*

S. K. MUKHERJEE, Calcutta.

A comparative study has been made of several routine methods for estimating the base exchange capacity (b.e.c.) of hydrogen clays, and hydrogen and acid soils. It has been shown that differences in (i) *p*H, (ii) 'cation effects' determined by the nature and concentration of cations present in the system, and (iii) time of interaction, account for the lack of agreement between results obtained by different methods. Parker's and Schollenberger's methods give nearly the same b.e.c. At the high concentration (N) of the salts and at the neutral reaction, the cation effect practically vanishes. Schofield's method gives a somewhat higher b.e.c. This may be accounted for by (1) the slightly higher *p*H (7·1) of the system, (2) the greater adsorption of Ca^{++} than Ba^{++} and NH_4^{+} in this *p*H region, and (3) the longer time of interaction (16 to 18 hours). Continuous titration (which takes about 6 hours) of hydrogen clays with baryta in presence of normal barium chloride gives a lower value, but if the titration is carried out in bottles allowing a longer time of reaction (about 16 hours), the observed b.e.c. is in good agreement with that given by either Parker's or Schollenberger's method.

Exchangeable hydrogen of some acid, as well as partly and completely desaturated soils determined by six different methods, has been compared with the T-S value obtained by Schollenberger's method. The methods of Kappen and Daikuhara give values in good agreement with T-S when the amount of exchangeable hydrogen is small but they give lower values for soils which contain larger amounts of exchangeable hydrogen. Titration with baryta in presence of N-$BaCl_2$ using a longer time of interaction gives higher values than continuous titration. Parker's $Ba(OH)_2$-NH_4Cl method and Schofield's method give values higher than T-S. These higher values are to be ascribed to the *p*H and time effects only. A lower value is obtained by Hutchinson and McLennan's method in which the *p*H is also 7·1. This is due to a smaller period of interaction (3 hours).

Crops and Crop Products

13. Investigation on Indian opium. Part I: Studies on the first lancing samples from some pure races of poppy plant (*Papaver Somnifera* Linn).

A. N. DEY, S. N. MITRA *and* C. PARTHASARTHY, Ghazipur.

Some commonly known varieties of poppy were grown in experimental plots under controlled conditions and the seed obtained by self-fertilization was gathered for each type. The cultivation was continued in this way for four years and ultimately 11 varieties of pure races of poppy were obtained. Samples of opium obtained by the first incision of the capsules

* This work has been carried out under a scheme of research financed by the Imperial Council of Agricultural Research, India.

of these plants were collected separately and analyzed. From a consideration of its morphine content, the opium was characteristic of the type of plant from which it was obtained. With the method of dry collection adopted, it was possible to secure opium of nearly the same morphine content even though the plant was grown in different localities. On storage the amount of morphine in such opium samples decreased partly, but this could be stopped by the addition of potassium fluoride (1%), which indicates that the process is due to some enzymic activity in the stored opium.

14. The effect of manurial differences on the quality of barley grains.

B. K. MUKERJI *and* R. R. AGARWAL, Cawnpore.

Samples of grains of barley (C 251) from a manurial trial, using four levels of nitrogen (0, 20, 40 and 60 lbs. per acre) at three levels of phosphoric acid (0, 15 and 30 lbs. per acre), were analyzed. It has been found that protein in the grain increases with an increase in the nitrogen level of manure, but decreases with an increase in the phosphoric acid level. Carbohydrates vary inversely as the protein content. Phosphoric acid in the grain is increased markedly by increasing the supply of this ingredient in the manure, but slightly so by increasing the nitrogen supply; whereas, lime is inversely related to the phosphoric acid content of grains.

15. Chemical examination of a few samples of honey collected from the United Provinces.

B. K. MUKERJI *and* R. R. AGARWAL, Cawnpore.

A few samples of honey collected from the Bundelkhand hill and *tarai* areas in the U.P. were analyzed. It was found that hill and *tarai* honey is whiter in colour and contains greater amount of glucose than honeys collected from plains. Bundelkhand honeys were found richer in minerals.

Agricultural Engineering

16. On proportionate rates of water in the three seasons of a year on canals in Bombay Deccan.

N. S. JOSHI, Satara.

The cost of construction of canal systems in Bombay Deccan, useful for monsoon, Rabi and hot weather irrigation, works out in the porportion 3 : 5 : 57. Figures of cost of construction of storage pick-up weir and canal are given for five systems of major canals in the Province of Bombay in support of the proportion mentioned above.

17. On quantities of water consumed per acre of cane (without overlap) on major canals in Bombay Deccan.

N. S. JOSHI, Satara.

Quantities of water consumed per acre under cane (areas under other crops being reduced to the basis of cane) per year for six large canal systems in Bombay Deccan vary from about 0·6 to 1·1 million cubic per acre as measured in the lake. The reasons for the variation and the influence of factors like river-flow, evaporation in lakes and losses in transit are discussed. Variations in requirements per acre are studied both for hot weather and the other periods independently, thus allowing the effect of each factor to be judged properly.

18. Sodium carbonate method of lining the canal beds with a view to minimizing seepage of water. Part IV.

M. R. Nayar *and* K. P. Shukla, Lucknow.

In a previous paper (*Proc. Ind. Sci. Cong.*, 1942, p. 200) it was noted that 'Usar soil' may be used as a cheaper lining material than sodium carbonate for minimizing seepage losses in canals.

An 'Usar soil' is a sodium soil containing varying amounts of free salts of sodium especially sodium carbonate. Hence in effect it behaves as sodium carbonate-treated soil, but its efficiency depends on exactly those factors which govern the suitability of a soil for sodium carbonate treatment, namely, a high clay content and a high base exchange capacity (*Proc. Ind. Sci. Cong.*, 1942, p. 73). Along with these other factors which are to be taken into account are:—

(1) The degree of saturation of soil complex with respect to sodium.
(2) The nature and proportion of salts present in free state.

The effect of (1) has already been discussed, while the effect of (2) has been studied in the case of some salts of sodium commonly present in alkali soils of these provinces, namely, carbonate, chloride and sulphate of sodium. It is found that increasing quantities of those salts increase the rate of percolation of water in saturated sodium soil. This effect is in the order: $Na_2SO_4 > NaCl > Na_2CO_3$. But as the concentration of these salts decreases by being washed away by the percolating water, the percolation rate tends to reach the value possessed by sodium saturated soil.

Field experiments with 'Usar' lining in the case of 'guls' have given satisfactory results and are being extended to small canals.

Agricultural Meteorology

19. Frequency of floods and droughts in India.

L. A. Ramdas *and* S. Gopal Rao, Poona.

The abnormalities in the rainfall of the last 66 years (1875–1940) in the 30 rainfall sub-divisions of India have been analyzed by using the criterion that a year in which the rainfall was above or below the normal by more than twice the standard deviation may be defined as a year of 'flood' or 'drought' respectively. The analysis has been made separately for four seasons of the year and for the year as a whole. The well-known floods of 1878, 1892 and 1917 and droughts of 1877, 1899 and 1918 in India are shown very clearly. Numerous tables and diagrams illustrate the paper.

20. Evaporation from soil columns resting on a water table.

A. K. Mallik, Poona.

The present paper describes the results of an experiment to find out the loss of water by evaporation from soil columns with the water table at different depths below the surface.

Three typical Indian soils, the black cotton soil of Poona, the red soil of Bangalore and the sandy soil of Trivandrum and five different distances, 9, 15, 21, 27 and 39 inches, between the soil surface and the water table were used. It was found that there is very little evaporation from the sandy soil of Trivandrum because water is unable to rise to the surface even when the water table is 9 inches below the surface. In both the other types of soil evaporation decreases very rapidly as the distance between the soil surface and the water table increases.

21. The effect of colour on the loss of water by evaporation from soil.

A. K. MALLIK, Poona.

The present paper describes how the colour of the surface affects the loss of water by evaporation from the black cotton soil of Poona under field conditions.

It has been shown that a thin sprinkling of chalk powder, just enough to make the surface appear white, reduces noticeably the loss of water from the soil. The moisture content of the plot covered with white (chalk) is appreciably higher than that of the control plot up to a depth of 8 inches.

22. Estimation of carbon dioxide in the air and soil layers near the ground in different environments.

R. K. MISRA, Poona.

A new instrument for taking out air from soil *in situ* is described. Values of CO_2 in the air and in the soil air in the open as well as inside cropped fields are given. It is found that

(1) inside the crops the CO_2 content of the air is always higher than in the open;
(2) in the soil air there is very much more CO_2 than in the air layers above the ground;
(3) there is a regular increase with depth in the percentage of CO_2 in the soil air.

Economic Entomology

23. The biology and economic status of *Enarmonia pseudonectes* Meyr. (Eucosmidae-Lepidoptera), a pest of sann-hemp in the United Provinces.

K. B. LAL *and* K. M. GUPTA, Cawnpore.

The sann-hemp plant (*Crotalaria juncea*), grown in the United Provinces for fodder and green manure, has been commonly observed to be infested by the caterpillars of *E. pseudonectes* Meyr., which make galls on the stems. The incidence of attacks increases from early August to the end of September, leading to an arrest of growth of the top shoots and appearance of many side-branches. The yield of fibre suffers deterioration in quality as well as in quantity, due to the presence of galls on the stems. Galled plants, however, produce more seed than non-galled plants. On the whole, *E. pseudonectes* must be considered injurious to the sann-hemp crop.

The life-history of the insect was studied at Cawnpore. Eggs were mostly laid on the leaves and hatched in 3 to 5 days. The larval period occupied 12 to 23 days and the pupal period from 4 to 8 days. Pupation occurred in the soil. During the three months, July to September, five overlapping generations were observed and the ratio of the males to females was about equal. Adults started mating about 24 hours after emergence and in the laboratory lived about 4 to 8 days on sugar solution. The larvae were parasitized by several species of Braconidae and Chalcidoidae, not yet specifically identified, which appeared to exercise a good check on the activities of the pest.

E. pseudonectes is not known from any part of India except the United Provinces and the Central Provinces. In the latter province it does not appear to be of much consequence.

24. Control of mango hoppers.

KHAN A. RAHMAN, Lyallpur.

There are three species, *Idiocerus clypealis*, *Idiocerus niveosparsus* and *Idiocerus atkinsoni*, which attack mango in India. Of them, only two species, *Idiocerus clypealis* and *Idiocerus atkinsoni*, occur in the Punjab.

Of the various poisons tried against these pests, sulphur dust proved most effective: it killed all the nymphs within 1–7 days and did not affect the mango flowers in any way. Half a pound of sulphur proved sufficient for 200–400 mango panicles at Hoshiarpur. Against adults sulphur proved a deterrent and remained effective for 4 to 6 days.

Observations on the effect of early and late flowering of mangoes on the incidence of mango hoppers showed that those varieties of mangoes which flowered during 12th–18th February suffered most, and those which flowered during 13th–18th March suffered least from these pests.

25. Technique of estimating the damage caused by the sucking type of insects to sugarcane.

KHAN A. RAHMAN *and* DALBIR SINGH, Lyallpur.

Pyrilla perpusilla Wlk. and *Macropes excavatus* Dist. rank among the most destructive pests of sugarcane in the Punjab. Adults and nymphs of both the species suck cell sap. The attacked plants become pale and wilt.

To study the effect of Pyrilla attack, sugarcane (Co. 285) was grown in a big field cage (20′× 12′× 10′) fitted with wire gauze. The cage was divided into two portions. In one portion, the crop was kept free from the pest while in the other portion the insect was introduced and allowed to breed. The crop in the two portions was given identical treatments by way of manuring, interculture and irrigation.

The observations were continued for two seasons: in the infested portion there were, on an average, 9 and 7 adults per shoot respectively in the beginning of the two seasons under review.

The analysis of the canes from the infested and uninfested plots revealed that in the former case, the percentage of total solids and sucrose and the purity coefficient were less while the glucose ratio was higher. The two seasons' results have been tabulated.

To study the effect of attack of *Macropes excavatus* Dist. on produce, sugarcane (Co. 285) was grown under identical conditions in two muslin cages. In one cage, the bugs were artificially introduced while the other cage was kept free. Towards the close of the cane-growing season, there were, on an average, 15 adults per shoot in the affected cage.

The chemical analysis of the bug-affected canes showed them to be poor in total solids and sucrose but there was an increase in glucose ratio.

26. Effect of carbon bisulphide on the germination of various seeds.

KHAN A. RAHMAN *and* GURCHARN SINGH SOHI, Lyallpur.

Various methods are advocated for the treatment of grain in bulk storage against pests of stored grain but fumigating the infested stock with poisonous gases has been reported to be the most efficient. Carbon bisulphide, because of its effectiveness and power of penetration, is considered to be the best chemical for this purpose, but so far no definite information is available regarding its effect on the germination of various seeds under Punjab conditions. Due to the exigencies of time, storage and preservation of various grains, such as wheat, barley and oil-seeds, have become very essential and in this paper data regarding the effect of

carbon bisulphide on the germination of these seeds are presented so as to make the fumigation method more popular.

The experimental technique is described. It has been observed that carbon bisulphide at the rate of one ounce for every 15 cubic feet of space with 24–36 hours' exposures or even longer can be effectively used for the fumigation of wheat, barley, toria, sarson, mustard and linseed without any deleterious effect on their germination. Higher doses, although they do not affect the viability of these seeds, bring about a retardation in the rate of germination of wheat and barley only. For example, a treated sample (with 2 oz. of carbon bisulphide per 15 cubic feet of space) gave 12·5% germination against 24·5% in the control on the first day of germination.

27. Pests of stored maize and jowar in the Punjab.

KHAN A. RAHMAN *and* GURCHARN SINGH SOHI, Lyallpur.

Maize and jowar are amongst the important crops of the Punjab. The grain obtained from these is stored to be used as and when required.

Various receptacles, such as baked earthen vessels, mud bins, bamboo bins, kerosine oil tins, gunny bags, baskets (for cobs meant for seed), are used for storing these grains: grain may also be stored in bulk in open heaps.

Sitophilus oryzae L., *Rhizopertha dominica* F., *Sitotroga cerealella* Oliv. attack maize and jowar in storage, sometimes doing serious damage. *Silvenus surinamensis* L. and *Tribolium castaneum* Hbst. have also been collected from those grains while *Latheticus oryzae* Waterh and *Laemophloeus* spp. have been collected from stored jowar only.

28. Preliminary trials with *Trichogramma* parasites for the control of the cotton bollworms (*Earias* and *Platyedra*) at Coimbatore.

M. C. CHERIAN *and* V. MARGABANDHU, Coimbatore.

Species of *Trichogramma* are well-known egg-parasites of economic importance used extensively in biological control work against some of the major pests of crops, such as the sugarcane borers, *Diatraea saccharalis* (Fabr.), the codling moth *Carpocapsa pomonella* (L.), the oriental fruit moth *Cydia pomonella* Busck, the European corn borer *Pyrausta nubilalis* Hbn., the American cotton bollworm *Heliothis armigera* Hbn., the world over. Utilization of these parasites for the control of the two cotton bollworms, *Earias* and *Platyedra*, has not so far been attempted elsewhere in India, and the results of the liberation of *Trichogramma* for their control is recorded in this paper.

The laboratory studies showed that these parasites attack eggs of both *Earias* and *Platyedra*. In the case of *Earias*, they attack one to three days old eggs; two parasites from a single host egg are not uncommon; the average life-cycle of the parasite within the host egg, from egg to adult is eight days; the emergence of parasites from host eggs is almost complete within the first two days and the number of eggs laid by a female in one instance was 125. In the case of *Platyedra*, the duration of life-cycle of the parasite is seven days; and only one parasite emerges from a single host egg.

With regard to field studies, eight fields were taken up for experimentation: four as controls and four for release of parasites. 5,000 parasites were liberated per release on each half acre once in four days. There were eighteen liberations in all, beginning from 17th December, 1941 to February, 1942, covering the first flush. The effect of the liberation was determined by comparing the relative infestation of the burst bolls in control and released plots. 80,947 burst bolls comprising 325,218

locks were examined, and the results are presented in two tables, and graphs are also given to show the trend of infestation; and from these it is seen that there has been reduction in incidence in the released fields as compared with the controls.

29. The Sweet Flag—*Acorus calamus* Linn.—a source of vegetable insecticide.

T. V. SUBRAMANIAM, Coimbatore.

Due to the difficulties of obtaining some of the insecticides in common use for the control of insect pests and due also to their highly poisonous nature in general and their exorbitant cost, attempts have recently been made to discover cheap, safe and easily available indigenous substances with marked insecticidal properties. Among the plant products tested for this purpose, the rhizomes and leaves of *Acorus calamus*—the 'Sweet Flag'—have shown promising insecticidal properties. This paper deals with preliminary trials with the rhizomes and the leaves against several insects, such as the Cholam weevil—*Calandra oryzae*—the housefly, bird lice and a few crop pests.

30. Preliminary trials with oil emulsions for the control of insect pests.

M. C. CHERIAN *and* E. R. GOPALA MENON, Coimbatore.

The paper deals with the results of the trials with emulsions of castor, groundnut and *neem* (margosa) oils against insect pests of crops. These emulsions possess a high toxic action against *Aphis gossypii*, *A. malvae*, *Eupterote mollifera* and *Epilachna 12-punctata*. The emulsions at the strength they are toxic to insects do not appear to have any deleterious action on the foliage.

31. *Orthaga exvinacea* Hmpsn., a pest on mango, and its control.

M. C. CHERIAN *and* K. P. ANANTHANARAYANAN, Coimbatore.

Orthaga exvinacea Hmpsn. is one of the pests on the mango tree in South India. The paper records results of observations, during the past two years, regarding the occurrence, life-history and habits of the pest. The insect is widespread, and its damage is easily located by the numerous clusters of webbed leaves found on the affected trees. The life-cycle is completed in about 45 days, when reared in captivity. Control measures found useful have been described.

32. Importance of plant protection in crop production.

T. V. RAMAKRISHNA AYYAR, Hyderabad-Deccan.

In order to utilize all available areas to grow more food crops several things are essential. Among these are the grant of land to poor farmers willing to take up such work either free or on attractive conditions, freedom from Government taxes or at least liberal concessions, supply of cheap seeds, free irrigation wherever available and even loan of implements and cattle.

Granting that all these facilities are arranged for and the ryot starts operations, he has to remember that his duties do not end there; for in crop production the protection of the growing crops from the depredations of the various agencies which damage them is a very important problem. For, in spite of the best attentions paid to the cultural, manurial and other requirements of the crop, in the absence of proper protection the crop would suffer severely from pests of different kinds, and the more so when food crops are grown on an abnormal scale all over the country, offering

unusual opportunities for them to multiply abnormally and harm the crops.

In this paper an attempt is made to explain the different aspects of this question with special reference to insect pests.

Plant Pathology

33. Relative study of the effect of different temperatures on the viability of Uredospores of wheat, jowar and *Bajra* rusts.

T. N. SHIVAPURI, Jeypore (Orissa).

(1) *Puccinia purpurea* (Jowar Rust).

Uredospores showing 98% initial germination suffered a gradual decline from 80% germination at 30°C. to 32% at 55°C. after six hours' treatment in Hearson's incubator. There was a further fall in viability to 4% at 60°C.

(2) *Puccinia Pennisetti* (Bajra Rust).

Uredospores showing 75% germination at 30°C. declined to 40% at 50°C. and there was total loss in viability at 55°C.

(3) *Puccinia glumarum* (Yellow Rust).

Uredospores showing 40% germination at 28°C. fell to 2% at 38°C. with total loss at 40°C.

(4) *Puccinia triticina* (Brown Rust).

Viability of Uredospores from 50% at 30°C. fell to 5% at 42°C. with total loss at 52°C.

(5) *Puccinia graminis* (Black Rust).

Viability of Uredospores was lost from 60% at 30°C. to 15% at 42°C. with total loss at 52°C.

Field observations also indicate that Uredospores of wheat and *Bajra* rusts lose their viability for infection after exposure to the sun and to the scorching heat of summer after harvest.

Plant Breeding and Genetics

34. Selection of strains in Arahar (pigeon pea).

T. N. SHIVAPURI, Jeypore (Orissa).

Next to paddy, pulses occupy the most important place as food grains, though Mandya or Ragi and Niger occupy more area in Koraput district where Arahar (Pigeon Pea) is intensively cultivated in the highland tracts with light sandy loam soil.

The average yield per acre of land is about 500 lbs. which is very low and the crop also suffers from 'Wilt of Arahar' caused by fungus Fusarium.

No attempt has been made so far in the province to evolve a high-yielding strain of Arahar resistant to disease.

This year a collection of the important local varieties of Arahar, namely, CHACHI Kandul, KA'BERI Kandul, KOLA Kandul, SI'RI Kandul and SUN'NAMANI, was made and grown in short observational strips.

Notes on the botanical characters of all the varieties grown are being taken so as to separate distinct morphological types present in these varieties and to make 200 to 250 single-head selections from each variety.

In regard to all these isolated strains, it is proposed, after testing for purity, to carry out extensive strain tests for isolating high-yielding strains.

35. Variability in Aman paddy.

P. M. GANGULI *and* J. L. SEN, Habiganj (Assam).

The fixed types of *Aman* (long-stemmed deep-water winter paddy), studied at the Deep Water Paddy Research Station, Habiganj (Assam), are classified into twenty-one popular groups according to their flowering dates, quality of grains, colour and size of unhusked grains, colour of apiculus and their probable capacity for withstanding flood. The variability in some of the quantitative characters, such as length and breadth of paddy and rice, weight per 1,000 grains of paddy, height of plants, number of tillers per plant, flowering duration and also the length of panicle and the number of grains per panicle has been studied for each group. The mean values of all the quantitative characters obtained for different groups have been compared. Correlations between some of the characters mentioned above have been studied.

Miscellaneous

36. Increase in crop yields through agricultural research and propaganda.

S. B. SINGH, Partabgarh (U.P.).

The rate of plant growth is conditioned by the internal characteristics of the variety as well as by external factors. Much work has already been done on improving the internal character of the plant by breeding and selection. The effect of external factors on crop production, however, requires further attention. The most important external factor affecting crop production is the fertility of the soil. However much one may try to increase production by better cultivation, adequate irrigation or by sowing more vigorous types, there can be no striking increase in the final yield unless soil fertility is also simultaneously improved.

It is a well-known fact that the Indian cultivator has not enough manure even for one-fifth of the total area that he cultivates. Much can be done to augment the existing supplies if the existing manurial resources are investigated.

Researches on the best green manuring crops, on the proper utilization of cow-dung and urine earth and tank silt and on the possibilities of increasing manurial supplies through mixed farming, are all urgently necessary.

SECTION OF PHYSIOLOGY

President :—B. NARAYANA, M.Sc., M.B., Ph.D., F.R.S.E.

General Physiology

1. The mechanism of gastric hunger contraction.

S. A. RAHMAN, Hyderabad-Deccan.

Gastric hunger contractions in a human subject were investigated. These contractions were not found to depend on blood sugar concentration which was not appreciably lowered during the period of contraction. Neither did the raising of the blood sugar level by intravenous injection of glucose or by subcutaneous administration of adrenaline abolish the contractions. The contractions were not affected by subcutaneous injection of pituitrine or ephedrine or by tightening of the abdominal belt. They disappeared almost instantaneously by drinking of 100 c.c. of water.

2. Gastric acidity in the newborn.

(MISS) HEMLATA MANGALIK, K. B. KUNWAR *and* V. S. MANGALIK, Lucknow.

Dutt-Chaudhari, and Chaudhari (1942) worked out the gastric acidity in newly born babies in Calcutta. An investigation on similar lines has been extended in the Queen Mary's Hospital. The study includes infants delivered normally, by forceps and by caesarean section. The age of the subjects has been variable—from a few minutes to a few hours. In some cases test has been repeated on several occasions on the same infant with a view to trace the changes in the gastric acidity in the first few days of life. A record of the haemoglobin percentage and red blood cell counts has been maintained.

Achlorhydria at birth has been found to be quite frequent. Relations between the quantity of gastric juice, free and total acidity with age, sex, height of the infants as also with complications at birth and parity of the mothers are discussed.

3. Haemoglobin survey of poor class families in and around Lucknow.

V. S. MANGALIK, Lucknow.

In 1941, a haemoglobin survey of poor class families was started in and around Lucknow. Persons with family income of Rs.15 or less per month were examined. Vast majority of these were employed as domestic servants, sweepers, or labourers in the city or in the fields. All subjects considered themselves to be in good health at the time of examination. In all 2,273 persons including children have been examined of which 1,727 were males and 546 females. Haemoglobin estimations have been made with Hellige Haemometer. Results of the survey have been analyzed with a view to show the mean haemoglobin value for this class of people in both sexes, as also to show the relation of age and haemoglobin content. The incidence of anaemia (persons with less than 10·5 grams per cent of haemoglobin) in a poor class population has been worked. In case of

women, figures have been analyzed from the point of relation of haemoglobin with child-bearing age. Relation of haemoglobin level with diet is discussed and an hypothesis is advanced. In spite of insufficient intake of food articles rich in iron, these people showed satisfactory haemoglobin levels because presumably of the iron they take in from the iron utensils in which their food is very often cooked. Inquiry has been financed by a grant from the Indian Research Fund Association.

4. Haemoglobin estimations on college girls.

V. S. MANGALIK, Lucknow.

While doing haemoglobin survey of poor class families in and around Lucknow, it was decided to make estimations of haemoglobin of the students of a local girls' college, majority of whom came from middle class families. In all 112 girls were examined—all boarders, and between the ages of 15 and 25 years. Mean haemoglobin level was worked out at 13·28 grams per cent. Subjects have been also classified into certain arbitrary haemoglobin groups and the findings in this survey discussed in the light of similar and more extensive survey on poor class families. It was found that in spite of marked difference in the economic status and consequently in the quality and the quantity of food intake in the two classes of subjects, there is comparatively insignificant difference in the mean haemoglobin levels.

5. Studies on the anti-anaemic concentrate prepared from Indian ox liver Part II.

U. P. BASU, Baranagar (Calcutta).

In continuation of a previous work (*Proc. Ind. Sci. Cong.*, 1941, Pt. III, p. 271) it is now being noticed that the nature of various aminoacids and their distribution in the anti-anaemic concentrate prepared from Indian ox liver do not appreciably vary whether the Cohn's fraction 'G' is prepared at 10°C. or at the room temperature (28–30°C.). The percentages of total nitrogenous bodies are found to be the same; but the yield in the concentrate is found to be greater in the latter case. This is also verified by isolating a greater amount of Reinecke acid salt from the higher temperature digest.

In no case the presence of tryptophane or cystine could be detected; whereas both contained lysine, arginine, histidine, glycine, tyrosine, oxyproline and proline in identical proportions. The reticulocyte response is being investigated with these and similar other fractions prepared under divergent conditions.

6. Vascular responses in frog's lung.

A. S. SINHA, Patna.

The effect of various drugs and also the effect of electrical stimulation of the vagosympathetic nerve and the medulla was studied on the frog's lung vessels. Injection of adrenaline caused vasoconstriction and the effect was either abolished or reversed by a previous injection of ergotoxine. Injection of acetylcholine caused vasoconstriction and this effect was abolished by a previous injection of atropine, and prolonged by a previous injection of eserine. Electrical stimulation of medulla caused vasoconstriction and the effect was abolished by a previous injection of atropine. Electrical stimulation of the vagosympathetic trunk caused vasoconstriction and this effect was not completely abolished by a previous injection of ergotoxine or atropine but the effect was completely abolished if ergotoxine and atropine were both injected previously. It was also noticed that the vagus nerve fibres had a weaker vasomotor control than the sympathetic on the lung vessels of the frog.

Pharmacology

7. Toxicity and absorption of soluble sulphonamide derivatives.

A. N. Bose, Baranagar (Calcutta).

In certain cases a parenteral administration of a sulphanilamide drug becomes necessary. But most of the drugs are not soluble. Various soluble products are in use but their relative toxicity and influence in raising the blood concentration of the drug have not yet been systematically studied. Accordingly a work of this nature has been undertaken in the present investigation.

The disodium salt of gamma-phenyl propyl amino phenyl sulphamide alpha: gamma disulphonic acid and the sodium salt of sulphanilacetamide seem to be two soluble effective drugs in parenteral sulphanilamide therapy. From the study on concentration of the drugs in blood in mice and that on the toxicity after intravenous as well as subcutaneous injection it appears that the toxicity of soluble sulphanilamide derivative seems to be independent of the liberation of sulphanilamide in the system.

8. The potentiation of the action of adrenaline by ephedrine on the small intestine of the rabbit.

T. C. Gupta, Patna.

Ephedrine potentiates the action of adrenaline on the rabbits duodenum. Adrenaline alone causes a reduction in tone and diminution in the intestinal contractions. After ephedrine, adrenaline in the same concentration gives a more marked loss of tone and a greater diminution in the intestinal contractions. The contractions, moreover, do not return to normal for a much longer time. This confirms the theory that ephedrine probably inhibits amine oxidase or any other enzyme responsible for the destruction of adrenaline thus leaving adrenaline to act more strongly and for a longer time.

Anatomy

9. The effect of specialization on the ligaments of the joints in the posterior limb.

Brijmohan Lal, Hyderabad-Deccan.

The tibial collateral ligament of the knee joint is double in Didelphys aurita which has the least specialized posterior limb, and in Dasyurus vivarrinus. The fibular collateral ligament is double in Didelphys. A fibrous band is found in Dendrolagus which passes from the outer surface of the meniscus, behind the joint superficial to the posterior cruciate ligament. It is attached to the lateral meniscus and the posterior horn of the lateral meniscus is joined to the lateral surface of the medial condyle of the femur and ligament of Wrisburg. In Chimpanzee a fibrous band passes behind from the posterior horn of the lateral meniscus to the anterior margin of the inter-condyloid fossa of the femur. In front it is attached to the apex of the patella. Eland has a ligamentum mucosa. The calcaneo-fibular ligament of the ankle joint is double in Dendrolagus, a comparatively primitive animal. Two more accessory ligaments were found in Dasyurus, and parameles in the ankle joint. Didelphys has two accessory ligaments on the lateral side of the ankle joint. The Baboon, and the Chimpanzee, which are more specialized, have less number of accessory ligaments. Man has got the least.

The more specialized is the limb, the lesser is the number of the accessory ligaments in the joint.

10. The relative contributions of the sympathetics from the lumbar ganglia in the innervation of the distal colon and the pelvic viscera.

G. K. GHOSH, Patna.

An attempt has been made from a comparative anatomical survey to evaluate if all the lumbar splanchnics are equally important. Water infiltration dissections have been carried out.

The evidences point to the existence and persistence of a segmental plan but with considerable overlapping in the distribution of the sympathetic to the distal colon and the pelvic viscera.

A general plan, at least in the primates and the carnivora, is the formation of three sets of lumbar splanchnic nerves. In man the middle series has the largest share in the supply of the distal colon and the lower series in the supply of the pelvic viscera. Below the level of the third lumbar ganglion, no splanchic has been traced to the presacral nerve or the I.M. plexus.

In the Carnivora, the third lumbar splanchnic forms the upper set, the fourth the middle, and the fifth the lower set.

In the Gubidiac, no contribution from the lumbar ganglion to the presacral nerve could be seen.

In the rodents, vami from the fourth lumbar ganglion is the only constant feature in the series.

In the ungulate, the lumbar splanchnic contribution to the distal colon is wholly from a branch from the fifth lumbar.

Nutrition and Biochemistry

11. The effect of nutrition on rat leprosy.

S. MAHDIHASSAN, Hyderabad-Deccan.

Rats kept in the climatic conditions of Bangalore on McCarrison diet rich in vitamins and salts were found to be immune to rat leprosy; those kept at Hyderabad on Bengal gram and lucern were susceptible to disease. Co-operation of others is required to confirm the findings observed in Bangalore.

12. The food and health of Kurmi-mahatos in Manbhum District.*

K. MITRA, Patna.

An investigation into the food intake of 200 Kurmi-mahato (semi-aboriginal) families consisting of 1,208 persons was carried out during the summer and rains of 1941. The food was found to be deficient in animal proteins, fats, calcium and vitamin A. Increase in income was not always followed by the addition of more of the protective foods. Though almost every family had a kitchen garden and a poultry of its own, the produce was usually sold in the market and only an insignificant portion thereof consumed by the producer. 1,462 boys and 960 girls between the ages 3 to 14 years and resident in the area were examined anthropometrically as also clinically. The percentage of malnutrition by clinical rating was found to be about 35%, whereas slightly lower figures were returned with the Knudsen-Schiotz index. About 10% of the boys and 5% of the girls were found to be suffering from either xerophthalmia,

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* Carried out under the auspices of the Bihar Government Nutrition Scheme at Public Health Laboratories, Bankipore, Patna.

phrynoderma or angular stomatitis. About 14% of the children were found to be suffering from dental caries.

13. The determination of food values by chemical methods of yet another batch of edibles.*

K. MITRA *and* H. C. MITTRA, Patna.

In the present investigation determination of moisture, protein, fat, ash, crude fibre, calcium and phosphorus content of 57 different kinds of edibles by chemical methods, has been presented. These consisted of 3 kinds of grain foods, 16 kinds of flesh foods, 9 kinds of fruits, 12 kinds of leafy vegetables, 11 kinds of root vegetables and 6 kinds of other vegetables. Fresh water crab (*Paratelphusa jacquemontii*) and one variety of prawn (*Palæmon lamareii*) were found to be rich in calcium. Six kinds of turtle's meat analyzed were found to contain about 15–18% protein and barely 3% of fat, the calcium content was low. In the leafy vegetable group the calcium content varied from 531 mg./100 g., in case of Parwar sag (*Trychosanthes dioica*) to 127 mg./100 g., in case of tender sarh sag (*Vangueria spinosa*). Lotus seeds and tubers of Ependong (*Peucedanum nagpurensis*) were found to be fairly rich in calcium.

14. Determination of the biological value of proteins from red ants (*Oecophylla smaragdina*) by the balance sheet method.*

K. MITRA *and* H. C. MITTRA, Patna.

As young red ants with eggs (*Oecophylla smaragdina*) are consumed raw by the Hos (aboriginal tribe) and Oriyas in Singhbhum district, an attempt was made to find out the biological value of proteins thereof. *Hau* (as the edible is known locally) was purchased from *hatias*, freed from extraneous matters, dried in the sun, powdered and stored in the refrigerator for use. Balance sheet experiments at 10 and 15% levels of protein intake were carried out with the powder using laboratory bred adult white rats in groups of six, as experimental animals. The average biological values were found to be 58·3 at 10% level and 55·6 at 15% level, though no significant difference could be found statistically between the two averages. The average digestibility coefficients were found to be 65·0% and 64·9% respectively.

15. The effect of muscular work on protein metabolism.

NARAIN DAS KEHAR, R. MUKERJEE *and* K. C. SEN, Izatnagar.

During the course of experiments carried out in these laboratories in connection with the investigation on endogenous nitrogen metabolism, opportunity was taken to study the effect of muscular work on nitrogen catabolism when the daily nitrogen excretion of bullocks on a N-free ration had reached a minimum constant level.

It was observed that muscular work (heavy cart driving) may be performed with no appreciable increase in the excretion of total endogenous nitrogen, urea, creatinine, creatin, total sulphur and total sulphates provided the increased caloric requirement during work be met with from carbohydrates and fats.

* Carried out under the auspices of the Bihar Government Nutrition Scheme at Public Health Laboratories, Bankipore, Patna.

16. The influence of soluble and insoluble oxalates in feed on the absorption of dietary calcium.

S. C. Ray, N. D. Kehar *and* K. C. Sen, Izatnagar.

The failure in the complete utilization of calcium by rats and man from vegetables rich in oxalates such as spinach is said to be due to the precipitation of calcium in the intestinal tract as calcium oxalate. The present investigation deals with the influence of oxalates in feeding stuffs in the absorption of calcium by ruminants.

Paddy straw, Napier (*Pannisetum purpureum*) and Guinea (*Panicum maxicum*) grass contain a large amount of oxalates and the major portion is present in the soluble form as potassium oxalate and almost the whole of insoluble fraction as calcium oxalate.

Paddy straw was fed to cattle and it was found that in spite of a large ingestion of oxalates for 30 days, only a small fraction was detected in faeces. The amount found in faeces was found quantitatively almost the same as the insoluble portion of oxalates ingested with the feed. Experiments conducted in this laboratory also showed that when a dilute solution of potassium oxalate was incubated with freshly collected rumen content, fairly rapid destruction of oxalic acid took place.

These experiments tend to show that unlike the case with one-stomached animals, the soluble oxalates in feed have no deleterious influence on the absorption of calcium in ruminants.

17. Intestinal absorption of iron.

Sachchidananda Banerjee, Calcutta.

There has been much controversy as to whether iron is absorbed in the ferric form or in the ferrous state or both. It is therefore of interest to study the intestinal absorption of iron in experimental animals such as rabbits. Different iron solutions were introduced into the lumen of an isolated loop of small intestine, four inches in length, of rabbits anaesthetized with urethane. The iron solution left unabsorbed in the loops after three hours was estimated for both ferric and ferrous iron. It was observed that within three hours about 44–66% of the injected iron was absorbed through the intestinal wall. Iron solution left unabsorbed in the intestine after three hours contained only ferric or ferrous iron depending on whether the solution injected was in the ferric or in the ferrous form respectively. When mucous scrappings from the small intestine was incubated with iron solution for three hours, only 8–12% of the ferric iron and 0–4% of the ferrous iron combined with the protein of the mucous scrappings and could not be recovered from the scrappings even after repeated washings. The absorbed iron, therefore, is not wholly cemented over the mucous membrane of the intestine or forms complexes with its protein. These experiments tend to show that the iron may be absorbed either in the ferric or in the ferrous form and the conversion of ferric iron to ferrous iron and ferrous iron to ferric iron is not necessary prior to absorption.

18. Manganese contents of the liver and small intestines of different species of animals.

M. N. Rudra, Patna.

Manganese contents of the liver and small intestines of man and guinea-pig are lower than those of animals and birds able to synthesize ascorbic acid.

19. The chemical composition and vitamin A potency of cow's milk and butter fat under intensive green feeding and the carotene metabolism of dairy animals.

B. C. Ray Sarkar *and* K. C. Sen, Izatnagar.

An experimental investigation has been carried out on the effect of a graded dose of carotene ingestion from a low value of 23,746 I.U. to a very high value of 3 million I.U. per day through different grasses such as green berseem, oat grass, etc., on (i) the chemical composition of milk and butter fat, (ii) the carotene and vitamin A potency of milk and butter fat, (iii) the carotene absorption, and (iv) the level of carotene and vitamin A in blood plasma.

The results obtained indicate that the chemical composition of milk remains the same, but the composition of butter fat undergoes some change tending to attain higher iodine number, R.M. value and Polenske value after intensive green feeding. The vitamin A potency is found to be identical (10,000 to 11,000 I.U.) per pound of butter fat when the daily ingestion varies from 1·5 million to 3 million I.U. Under the condition of feeding 1·5 million I.U. daily, the percentage excretion of carotene in faeces is about 70 and the recovery of carotene in butter amounted to only 0·09% of the total intake, which shows an enormous wastage. The concentration of carotene and vitamin A in blood plasma also shows a significant increase on green fodder ingestion.

20. Conversion factor for the spectroscopic estimation of vitamin A in Indian fish liver oils.

G. B. Ramasarma, Bangalore.

It is well known that, for the spectroscopic determination of vitamin A, different conversion factors should be used in the cases of cod liver oil and whale liver oil concentrates. There has been also a considerable amount of controversy over the correctness of the officially accepted factor 1,600. Experiments are being carried out with a view to finding a factor applicable to Indian fish liver oils. A sample of undiluted 'Shark Liver Oil' (kindly supplied by the Government Oil Factory, Calicut) gave on spectrophotometric examination a value of $E^{1\%}_{1\,cm.}$ 325 mμ = 2·8. Biological assay on depleted rats using pure β-carotene (S.M.A. Corporation's) as standard showed that the oil possessed a potency of 5,910 International Units per gram. The conversion factor thereby derived is 2,100.

21. Determination of vitamin C and carotene in various herbs, plant leaves, flowers and flower hips.*

G. K. Ray, N. M. Basu *and* N. K. Dey, Calcutta.

About 50 kinds of herbs, plants, leaves, flowers and their hips used in the preparation of Ayurvedic medicine were examined as to their carotene and ascorbic acid content. Neem leaves, particularly the sprouting ones, gave very high figures. The lowest figure for ascorbic acid was obtained from *Pudina* or mint leaves. The loss or otherwise of ascorbic acid in some of these leaves due to frying in oil was also determined. In some cases an increase in ascorbic acid content was noted. In the case of *uchhay sag* (leaves of bitter gourd) no change could be noticed even on repeating the experiment for a second time. The cause of these variations has been discussed.

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* Carried out under the auspices of the Indian Research Fund Association at the Presidency College, Calcutta.

22. Note on the chemical method of estimating ascorbic acid.

M. N. RUDRA, Patna.

The use of metaphosphoric acid or pyrophosphoric acid has no advantage over trichloracetic acid alone when the modified method followed in the author's laboratory is used for estimating ascorbic acid. Ascorbic acid oxidase treatment method is unnecessary.

23. Rôle of manganese in the biological synthesis of ascorbic acid.

M. N. RUDRA, Patna.

Guinea-pigs on scorbutic diet have been found to synthesize ascorbic acid after injections of manganese chloride solution with or without sugar by determining the ascorbic acid contents of their intestines.

24. Ascorbic acid content of blood in women before and after delivery.

K. D. LAHIRI *and* M. N. RUDRA, Patna.

Ascorbic acid content of whole blood in women before and after parturition has been determined. The values obtained were 0·90 mg. and 0·52 mg. respectively per 100 c.c.

25. Vitamin content of 'Amla' powder on storage.

S. K. ROY, Lahoriaserai.

The vitamin C content of 'Amla' powder on storage up to three years has been determined. It has been found that storage in amber coloured bottles preserves a substantial amount of the original vitamin content even for three years.

26. Relation between ascorbic acid (vitamin C) and calcium metabolism.

N. K. BASU, Delhi.

Apart from the relation between vitamin D and calcium, which is already well known, a good relation has been found between vitamin C and calcium metabolism.

The paper deals with the experimental as well as the clinical aspect of the question to show that for production of the desired effect of calcium in the system, a definite amount of ascorbic acid must be present simultaneously.

27. Liver extract and ascorbic acid in arsenical intolerance.

K. D. LAHIRI, Patna.

The detoxicating function of the liver in arsenical intolerance has been found to be lowered and the ascorbic acid content of the whole blood has also been found to be low in arsenical intolerant cases. The administration of liver extract and ascorbic acid improved the detoxicating function of the liver and the blood ascorbic acid level was also raised. Arsenical therapy in these cases could be resumed without any relapse of the symptoms.

28. Assessment of nutritional status of boys in Lucknow schools by somatometric tests.

B. G. Prasad, Lucknow.

Assessment of nutritional status was made in two representative Lucknow schools during April and May 1942 to test the value of somatometric methods of assessment.

The following data were collected for each of 139 boys:—

1. Weight.
2. Height.
3. Chest girth.
4. Chest depth.
5. Sitting height.
6. Wrist girth.
7. Arm girth.
8. Bis-iliac diameter.
9. Bis-acromial diameter.
10. Intertrochantric diameter.
11. Thickness of subjacent tissue over chest, abdomen and back.

Averages in relation to age have been drawn and graphs prepared.

Indices calculated from some of the above data have been recommended previously and all of them are included in the special report by the League of Nations' Commission on Nutrition. All these indices (12 in number) have been calculated and their value as indicating the state of nutrition correlated with each other, as well as with a classification of physique by direct observation and with scoring of child's health by the absence of evidence of minor diseased conditions ('defect score'). None of the indices proved satisfactory and no two indices involving independent data showed significant correlation with each other. No correlation was revealed between the indices and classification of physique by direct observation.

A.C.H. index was determined for a group of students of average economic status (139) and another one of a very bad economic status (87). Contrary to experience in South India and the U.S.A., the A.C.H. index failed to pick out more than 3% boys.

It is concluded that no somatometric index can be relied upon to detect malnutrition.

29. Effect of vitamin C on the glucose tolerance test in guinea-pigs under various conditions.

Sachchidananda Banerjee, Calcutta.

Glucose tolerance test has been performed on scorbutic guinea-pigs, guinea-pigs on normal diets, guinea-pigs on normal diets receiving injections of ascorbic acid, partially depancreatized guinea-pigs and partially depancreatized guinea-pigs receiving injections of vitamin C. Scorbutic guinea-pigs showed definitely lower glucose tolerance than guinea-pigs receiving normal diets both with or without the supplement of vitamin C. The sugar tolerance in the pancreatectomized guinea-pigs receiving injections of vitamin C was higher than pancreatectomized animals without the supplement of vitamin C but the tolerance in the former group was definitely lower than the other groups. The use of vitamin C in the treatment of diabetes mellitus is suggested.

30. Experimental studies on the influence of vitamin B_1 on the inflow of phosphates in the intestinal canal and the absorption of glucose therefrom.*

N. M. Basu *and* G. K. Ray, Calcutta.

Influence of thiamin on the inflow of phosphates and absorption of sugar in the intestine of the rabbit has been studied on animals starved

* Carried out under the auspices of the Indian Research Fund Association at the Presidency College, Calcutta.

previously for 24 hours. After laparotomy was done, two loops of intestine, each 30 cm. long, were isolated by ligatures. In one of these loops hypertonic solution of glucose and in the other the same solution with 10γ of added thiamin were injected. In some of the animals tyrode solution was injected in place of glucose. Quantitative estimations of glucose and phosphates in the aliquot portion of the contents of the isolated loop were made after 20 minutes and 1 hour of the injections.

Only minute quantities of phosphates could be detected in the loops containing tyrode solution only, whereas much larger amounts of phosphates were found in the loops with added thiamin. In the case of loops filled with glucose, phosphates were present in appreciable amounts but much less than in those with added thiamin. It was also noticed that absorption of glucose was much higher in loops with added thiamin. It appears that thiamin influences the inflow of phosphates in the intestinal canal and the absorption of sugar therefrom.

31. The sources of nicotinic acid in human diet.

G. S. SAHARIA, Agra.

Nicotinic acid and its amide play an important rôle in nutrition. The present paper records an investigation into the nicotinic acid contents of the various Indian foodstuffs. A chemical method, however, based on the König's reaction has been adopted in the present series of investigations. Nearly one hundred and fifty foodstuffs have been estimated for their content of nicotinic acid. Yeast is found to be the richest source with a minimum figure of 66 mg. per 100 gm. Next in order fall cereals, legumes, nuts, vegetables and fresh fruits. Amongst the legumes, groundnut gives an extraordinarily high figure of about 20 mg. per 100 gm. and as such it should form an indispensable part of one's diet due to its cheapness, besides its high calorific value and protein content.

32. Annatto dye.

G. B. RAMASARMA, Bangalore.

Annatto dye is extensively used for colouring butter and other edible oils and fats. In the literature there have been occasional statements to the effect that the dye has vitamin A activity or that it may exert a toxic action. It was, therefore, thought to be of interest to test the effect of feeding the dye to experimental animals.

Feeding trials on white rats have shown that the dye prepared by the sodium carbonate extraction method (kindly supplied by Prof. K. Venkataraman) possesses neither vitamin A potency nor any apparent toxic effect when a 0·1% solution of the dye in cocoanut oil or groundnut oil constituted 10% of the diet.

SECTION OF PSYCHOLOGY AND EDUCATIONAL SCIENCE

President :—B. L. ATREYA, M.A., D.LITT.

General Psychology

1. A case for psychology.

N. MUKERJI, Calcutta.

Evolution of psychology as a science—Psychology as related to other branches of social science—Retarded growth of psychology as well as other social sciences and the reasons—Exploitation and misuse of the outcome of researches and studies—No likelihood of development of the social sciences in our form of society—Suggested platform for the workers in the field of social sciences.

2. Psychology and music.

(MRS.) BANI CHATTERJI, Calcutta.

Psychology and music are inter-related. Psychology implies a study of the emotions. Music offers an ample scope for it: (*a*) The mind responds readily and sympathetically to music—with realistic effects. (*b*) The relation of the mind to music is 'like music like emotion'. (*c*) Facts tend to show that the emotions can be determined and controlled by an appropriate music. (*d*) Instinctive appeals produced in the mind decide the name of a music. (*e*) Mind, individually and collectively, can be directed to physical movements by the emotions in the music. (*f*) An outburst of mental feelings finds an easy escape through music.

Thus, *music* by virtue of (1) its power for refining and educating the mind, (2) its power for determining and controlling the various mental emotions, (3) its being an easy access to the mind, and (4) its being of considerable practical utility to the mind, proves to be of immense value in *psychology*, theoretically and practically alike.

3. Sensation, perception and immediate consciousness.

RAM MURTI LOOMBA, Delhi.

The concept of sensation and of perception and the view of their relation as particularly reformulated by Woodworth by his introduction of the conception of mental reaction is critically examined and found untenable.

The paper puts forward the hypothesis that perception arises not out of sensation but by a spontaneous self-differentiation of immediate consciousness, the nature of which has been formulated in an earlier paper (*Proc. Ind. Sci. Cong.*, 1938 and *Ind. Jour. Psychol.*, 1938). Sensation is a hypothetical construct arising as a result of a differentiation of perception which is not spontaneous but motivated by the analytical ends of psychological science.

4. An experiment in rumour.

N. Mukerji, Calcutta.

The object of the experiment was to examine the qualitative and quantitative changes that appear in a statement when it is conveyed from one person to another.

Different groups of school students, college students and professional men participated in this experiment. No group exceeded ten persons.

A 'news sheet' bearing 'news' of Russo-German and Sino-Japanese wars, political movement in India and events of topical interest was supplied to one person in the group. A pause was given when the subject had finished reading, after which he was asked to pass over the news verbally, the news sheet having been taken away from him, to the next person. The second subject had to write down what he had heard and return the slip to the experimenter. He then passed the news to the third person. Instructions were given that no alteration was to be made in the facts and figures supplied while they were being conveyed to the next person. A set of questionnaire was used to gauge the subjects' attitude towards the major world events of the day.

Results obtained indicate how distortion of facts takes place according to one's attitude towards a warring country or a political party.

5. The integration of personality.

Indra Sen, Delhi.

G. C. Jung in his book named as above arrives at a most interesting conclusion regarding the nature of personality. He says that every kind of psychological description is inadequate, and that an 'irrational factor' seems to be necessarily involved in it. Jung himself goes no further. But he does obviously raise the question: What is the nature of this irrational factor and whether for a complete or even a satisfactory account of human personality an excursion into the metaphysics of psychology is avoidable? It appears as though the psychologist like the modern physicist is going to surpass himself.

Besides this, Jung makes one or two other judgments which also are examined. He says that the yogic '*samadhi*' is a state of unconsciousness and that the so-called 'superconsciousness' is identical with it. The author of this paper, however, contends that there seems to be evidence enough of a distinct range of experience to point the superconscious.

6. Spearman's tetrad difference criterion and the group factors.

S. M. Mohsin, Patna.

The coefficients of correlation in a table of inter-correlated mental test results show a characteristic hierarchical arrangement which can be explained only according to Spearman's Two-Factor Theory. The hierarchy can be detected by the application of the tetrad difference formula:—

$$(r_{ab} \times r_{cd}) - (r_{ad} \times r_{bc}) = 0.$$

The equation can be satisfied only when the correlations are determined by the single general factor, Spearman's 'G'. Consequently, when some factor, entering into a few and not all tests in a battery, partly determines some of the positive correlations, the equation is not likely to be satisfied. Such overlapping factors have been termed as the group factors.

Two different types of overlapping factors have been considered: (1) Book Learning, and (2) Manual Work. The results are in conformity with the Two-Factor Theory.

7. The concept of vicarious trial and error.

N. N. SEN GUPTA, Lucknow.

The maze-behaviour of rat which is called to-day the vicarious trial and error or V.T.E. has a long history. It has been considered by Lashley, Hoge, Peterson, Tolman and several other psychologists of later date. The present paper is an analysis of this line of work.

8. An aspect of the method of administering individual intelligence test.

D. GANGULY, Calcutta.

In this paper it is reported that an investigation has been set up in the Calcutta Psychological Laboratory to find whether the factor of cognizance of test results during testing influences the score of a testee. Data are now being collected for all possible variable situations. A tentative conclusion has been attempted on the basis of data so far collected.

9. The field of psychology and the rôle of war.

S. SINHA, Calcutta.

In Europe and America the psychologists are playing no insignificant part during war by helping the State to select the right type of personnel for the different services, to conduct propaganda for keeping up the public morale and looking after the mental welfare of the fighting forces. The present paper gives a short résumé of the work being done there and suggests certain concrete proposals regarding the ways the Indian psychologists can help war preparations, provided the Government is disposed to avail of their co-operation.

10. 'Attenuation' effect on '*r*' between initial score and gain with practice.

S. K. BOSE, Calcutta.

In a paper contributed to this section in 1941 the present writer discussed the methodological issue involved in the problem of variability in achievement with practice and came to the conclusion that under certain limitations convergence of final scores is the usual outcome. Since then he has carried out experiments with the Cancellations and the Continuous-Multiplication Tests, and has corrected the results for the 'attenuation' effect as suggested by Syrkin and Anastasi. It is now found that the convergence is more apparent than real. This tends to a modification of the previous conclusion and favours the proposition that individuals are likely to maintain the same relative positions during practice. The final conclusion in the matter awaits further investigation.

11. Laws of association.

UDAI BHANU, Indore.

Experiments on animals performed in the laboratory under strict control cannot adequately explain the laws governing human functions because of ideational complications and motivation. In actual life, the higher mechanisms build up various modes of behaving to the same stimulating object.

My experiments prove that the law of contiguity needs adjustment. The bond established between different objects depends upon their

properties and the order of presentation. The following results are obtained:—

I. The first and the last positions in the group are most favourable to learning.
II. The ninth item, i.e. last but one was the most unfavourable position.
III. The law of contiguity and recency does not prove valid when a series of material is used.
IV. Association is greatly facilitated if the material is presented in a particular order.
V. The conductivity of nerve fibres joining the points which are to be linked varies from time to time.

12. Determination of D.L. in the field of kinaesthetic sensitivity.

S. C. MITRA *and* S. N. ROY, Calcutta.

The purpose of the experiment is to determine the D.L. value in the sphere of kinaesthetic sensitivity. Fully stretched hand is moved between limits both in the vertical and horizontal directions. Gradation method and Constant method are adopted. Comparison is made between the two sets of D.L.'s (vertical and horizontal). Possibilities of usefully applying the data in practical fields have been suggested.

13. A study in the visual estimation of frequency and number.

(MISS) SHANTI AGARWAL, Lucknow.

The experiment intends to study the visual estimation of frequency and number. This experiment was carried on 135 female students studying in the Mahila College. They were all healthy and active. They generally belong to educated middle class families.

The material for the experiment consists of two sets of cards having certain numerals on them. One of these sets is to be divided into two sides. For the first set, subjects were required to give an approximately correct answer and in the case of the second set they had to compare two sides and give their judgment of 'greater' or 'less' on the appropriate side. The time of exposure, in this case, was two seconds only. This was so, because the aim of the experiment was to avoid counting.

From the experiment it may be concluded that the variation of answers depends both upon age and experience of the people.

14. A psycho-physical interpretation of the sound-experience connected with the 'Unrecited mystic syllables'.

N. N. SEN GUPTA, Lucknow.

The paper begins with an analysis of the phenomenon on the basis of authoritative texts and testimony that some of the experiences described actually occur. It ends by suggesting an explanation in terms of the auditory mechanism.

15. Psychological analysis of the vocation of mechanic.

S. N. ROY, Calcutta.

Psychological analysis of vocations is one of the essential features in problems of vocational guidance and vocational selection. The present paper reports a preliminary analytical study of the vocation of mechanic. Some recognized tests and a few others specially devised for the present purpose have been administered to a group of mechanics attached to the different departments of the University College of Science and Technology,

Calcutta. Description of all the above tests, the methods adopted and the results arrived at have been discussed.

Child Psychology

16. The growth of the speech-function.

N. N. Sen Gupta, Lucknow.

The paper gives an analysis of speech in the earlier years of life. It lays stress on the unverbalized planes of behaviour on which speech depends and traces the various stages in the development of speech.

17. A study into the poetic interests of young children.

Jagdish Singh, Preet Nagar (Punjab).

A set of eleven poems specially composed for children of the primary stage in their spoken language formed the subject of this investigation. The subjects of the poems centred round familiar topics of everyday interest for children. Poems were read aloud to the children and data were obtained for their likes and dislikes. An attempt is made to find out the causes of their likes and dislikes.

18. Humour in children.

Rabi Ghosh, Calcutta.

Very early in life human beings demand pleasure and the release of psychical tension. While growing up, the human psyche had to accept frustrations, disappointments, renunciations, etc., and had to impose restrictions of various kinds. Adult-way of doing things differs from the child-way. Child is in a dilemma to become adult-like and to accept Super-ego commandments, and to rebel against the adult attitude and the Super-ego. Humour is sought for to resolve such a dilemma. Few typical cases of humorous behaviours are used as examples illustrating the child's sense of humour.

19. A study into the colour preferences of children.

Jagdish Singh, Preet Nagar (Punjab).

In this investigation an attempt was made to study the spontaneous colour preferences of children. The material used for experimentation was a monthly children's magazine (*Bal Sandesh* in Panjabi). It displayed its title in a different colour each month. All the twelve issues of the magazine for the year 1942 were taken together and a concensus of opinion obtained with regard to the different colours.

Educational Psychology

20. Intelligence testing in India and mental deficiency among the school and college students.

S. Jalota, Sholapur.

Mental deficiency among the school and college students in India has been reported by several workers. But their results have been based upon norms determined for European or American children. I have attempted a number of norms for finding the I.Q. of my testees (about 2,300 students). This paper reports these results: the percentage of backward candidates is higher; but the percentage of geniuses is also

much higher. This may be explained by considering some test-items to be too difficult for the average students in India; and a large number of test-items to be too easy for the better students in India. The large percentage of mentally backward students may also be explained as due to the lenience of school and college authorities: even university examiners have a tendency to promote a number of doubtful along with the borderline cases.

21. Motives for education abroad.

RABI GHOSH, Calcutta.

Every year a large number of students from India go abroad for higher education. Not a few cases there are amongst them who show neurotic manifestations in following the motives, underlined in their attempts. Few cases are analyzed to discover such motives. Libidinal gratifications, parity of the Ego with the Super-ego, narcissistic over-valuation, increment of the sense of guilt are the findings.

22. Certain observations in regard to the training of children in a Montessori school.

(MISS) SHANTI AGARWAL, Lucknow.

In this paper the author has described certain observations in regard to the advantages and difficulties of the Montessori method in teaching alphabets and numerals to children. There is no doubt that the method and the material are of immense use in training children, but I find that they do not satisfy the needs of Indian girls. In my school I have observed a great deal of sex difference in the tastes. Out of the whole lot of material, girls would like to play with colour tablets, coloured-triangles, and stamp-cards. Probably they like coloured objects more. Boys like to play with the things which help them in building bridges, tower, rail-roads, and houses, etc. In the case of free games and potter's work too both the sexes differ. To meet the needs of the girls I have introduced certain other things in my school.

Besides this I find that the application of other Montessori principles is also very difficult in the case of Indian children. For instance, there are certain difficult children who cannot be made social, independent, and disciplined.

23. The problem of overaging in A.V. middle girls' school—individual cases.

(MISS) T. HABIBULLAH, Lucknow.

This paper deals with overaging by a study of individual cases in the Talimgâh-e-Niswân, an A.V. Middle Girls' School. (I) The amount of overaging of each overage-child. (II) Her scholastic record. (III) The likely causes of overaging are discussed. The sample chosen was fairly good because there are girls of various types of mental calibre as well as of all groups and strata of society, because the school chosen admits all classes of girls.

24. A new arithmetical apparatus.

RABI GHOSH, Calcutta.

An objective approach to the teaching of numbers and arithmetical thinking is made. Numbers and arithmetical problems are very abstract. This apparatus has been devised for the education of children in nursery and pre-nursery years. Instructions for the use of the apparatus are

so easy to follow and the price of the apparatus is so cheap that even middle class parents can adopt it for teaching their children at home.

25. Differentiation of curriculum for boys and girls.

K. D. GHOSE, Dacca.

The problem a very old one though unsolved—ancient India and Greece—questions of identity of intellect and interest, social functions and specialization—revolution in men's ideas about women and women's occupations brought about by the two world wars—man to be man-like and woman to be woman-like or uniformity through education—modern investigations carried out in the West by Thorndike, Burt and others approached mainly from physiological and intelligence quotient standpoints and not so much from the mental outlook point of view—the findings—no great differences needing a clear-cut differentiation—difficult to agree—a questionnaire issued by the writer of the present paper—interests of the boys and girls on the basis of the answers received—what amount of differentiation desirable in spite of the obvious parity in intelligence and intellect—the new matriculation curriculum of the Calcutta University and the Board of Secondary and Intermediate Education, Dacca—the curriculum as based on the differing interests and the social and biological needs of girls and boys—the future.

26. Educational needs of Bengal in relation to employments.

S. DATTA, Calcutta.

Assuming that the energy of a nation is best conserved if there be a planned education of the people suited to their future avocations, an analysis has been made of the number of persons employed in different vocations from the available census figures. These have then been suitably grouped according to their educational needs and an estimate of the number of persons in each group has been arrived at. From this the number of schools required for different educational groups have been found out.

Similar analysis for the needs of other provinces are in progress.

Abnormal Psychology

27. The psychogenesis of epileptic seizures.

I. LATIF, Lahore.

The case of a young man is presented whose epileptic attacks date from his early boyhood. An attempt is made to analyze the aetiological factors of epileptic seizures. Repressed, murderous hostility stands out as one of the most fundamental factors of the disorder in question.

28. On the psychology of depressive states.

PARS RAM, Lahore.

Moments of depression in the patients, under observation, were accompanied by the following symptoms:—

1. Bodily symptoms of motionlessness, tendency to lie in bed in a particular posture and irregular respiration. Some patients showed inability to control saliva.
2. Mentally the feeling of being left alone, apathy, helplessness and self-criticism stood out prominently. Disturbed sleep and inability to go to sleep were also noted in some cases.

The symptoms are nothing more than a revival of the childhood stage of development and suggest that depression is the continuation in the ego of an infantile mode of meeting a situation. No treatment or improvement is possible unless the patient is able to fully realize this. That is only the beginning of the treatment. A thorough-going treatment will have to bring to the patient the early situation of human relationship to which he reacted with depression. Associations in one patient suggested his identification with a sexually excited patient. The rôle of bisexuality is by no means unimportant.

29. A study of war-neuroses.

K. D. GHOSE, Dacca.

The present article is based on a study of one hundred men, women and youths who have recently evacuated from Burma and settled themselves down at Dacca and Mymensingh—the condition of the vast majority who had seen and heard bombs bursting in the neighbourhood is more or less normal except a violent shake-up.

The effects continued both in the mental and physical plane even after their arrival in India—gradually recovering from the shock—a few cases of definite neuroses due to fright of various kinds and degrees and repression of war experience—details of such cases with the symptoms—one or two cured owing to a happy re-union with the relatives who returned later from Burma—treatment suggested with regard to the rest of the cases. The necessity of more intensive and extensive investigation.

30. Psychological factor in headache.

PARS RAM, Lahore.

Observations on headache reported in this paper are based on observation made on five women patients. Circumstances prior to the beginning of headache are carefully analyzed. All the patients showed violent emotions which they had not learnt to analyze. The situations demanding a moderated and refined emotional response always resulted in headache. The hidden ambivalence which was at once the cause of violent emotion and headache was unearthed resulting in relief. Headache is a symptom of the aggression turned inward. Attempt is made to explain as to why head is chosen as the organ for expressing the conflict.

SECTION OF ENGINEERING AND METALLURGY

President:—N. V. MODAK, B.E., M.I.C.E., M.I.E.(India), M.I.M.CY.E., F.R.SAN.I., J.P.

1. Data likely to be useful in working out economics of irrigation canals in Bombay Deccan.

N. S. JOSHI, Satara.

The paper gives figures of costs of different parts of irrigation systems in Bombay Deccan which will be useful for working out rough financial figures for a project. These include tables for costs of storage reservoirs, pick-up weirs, canals, distributaries, drainage and reclamation of lands. The paper also gives a résumé of the losses in various parts of an irrigation system. Duties obtained and revenue.

This data is useful in working out the cost of a proposed irrigation system in Bombay Deccan for a preliminary estimate to serve as a useful guide before making costly surveys and detailed estimates.

2. Voids in materials of construction and method of making allowance for the same.

N. S. JOSHI, Satara.

The paper discusses the question of allowing for voids in the materials of construction, like road metal, chips grit, gravel and sand. The practice obtained at present is to deduct for these voids a certain percentage as under:—

Small grained material like sand	Nil to 5%
Medium size material like road metal, gravel, Kanker	5 to 10%
Large size material like hard murum	12 to 18%
Small size rubble for soling, etc.	15 to 25%

The underlying idea appears to be the erroneous assumption that larger the size of the individual piece the larger the percentage of voids.

The paper shows that the voids are independent of the diameter of the pieces or particles of the material so long as they are the same size. Proof is given for spheres and it is shown mathematically that:—

(*a*) In the case of rectangular arrangements of spheres voids are about 48%

(*b*) In the case of equilateral arrangement in two directions voids are about .. .. 30%.

The same is verified by experimenting upon various materials and it is shown that voids in material actually met with (which cannot be mathematically spherical) is about 35% in gravel. It is 50% in broken metal and this is due to the peculiar shape of the material. Voids do not change with diameter of material, viz. gravel or metal, but it does change with the shape.

Proceedings of the Thirtieth Indian Science Congress

PART IV—LATE ABSTRACTS, ERRATA AND ADDENDA, DISCUSSIONS, LIST OF MEMBERS AND INDEX

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Proceedings of the Thirtieth Indian Science Congress

CALCUTTA, 1943

1. LATE ABSTRACTS

Section I, Mathematics and Statistics.

24. Formation of the arms of a spiral nebula.

BRIJ BASI LAL, Allahabad.

In the first part of this paper variable angular velocity is taken into account and it is shown that the gravitational force alone cannot form equiangular spirals. In the second part it has been shown that the equiangular spirals are formed on the basis of Van-Maanen's measurements, that the velocity increases on passing outwards in a nebula.

25. Adiabatic radial pulsations of the generalized Roche model.

SUNIL KUMAR ROY, Allahabad.

Considering the symmetrical adiabatic oscillations of a star of the generalized Roche model, it has been shown that free periods with characteristic terminated series solutions for the amplitude function can be obtained for a characteristic set of density laws in the rarefied envelope, and the correspondence of these periods with the period for a finite core have been given as a function of the radius of the core. In considering the fundamental oscillation, we have determined the only type of density function where we can obtain the expression for the periods. Of these models one had been considered by Sterne, and all the others are characterized by a zero density on the boundary of the star. A study of the characteristic periods shows that the periods of a Roche model depend not merely on the mass and radius of the core, but also depend widely on the law of density in the atmosphere, even though we have assumed the mass of the atmosphere to be negligible compared to that of the core.

26. Note on a method of operational solutions of problems in the propagation of heat.

S. C. DHAR, Nagpur.

The problem of the propagation of heat in isotropic solids is generally solved by substituting p for $\frac{\partial}{\partial t}$. Further it was shown by Ganesh Prasad that certain solutions fail at the critical values of time and of co-ordinates. He had therefore suggested that heat-propagation in an infinite solid should rather be represented by an integral equation,

$$k\int_0^t \frac{\partial v(x,\,t')}{\partial x}\,dt' = \int_0^x [v(x',\,t)-f(x')]\,dx',$$

which one can get from the principle of conservation of heat-energy, instead of the usual differential equation,

$$k\,\frac{\partial^2 v}{\partial x^2}=\frac{\partial v}{\partial t}.$$

It will be seen that the former is the subsidiary equation of the latter according to Heaviside. Now by the method of simultaneous operational calculus, the solution of the latter and therefore of the former can be obtained.

27. Nul lines and linear complexes.

F. J. NORONHA, Bangalore.

The Nul lines of a system of forces in three dimensions constitute a linear complex given by the equation;

$$lL+mM+nN+\lambda X+\mu Y+\nu Z = 0$$

where $(l, m, n; \lambda, \mu, \nu)$ are the Plücker co-ordinates of a nul line, and (X, Y, Z), (L, M, N) are the components of the equivalent force and couple, respectively, relative to the origin. Properties associated with nul lines and deduced by the application of Statical principles give rise to corresponding properties associated with linear complexes in general.

Besides, the lines of a linear complex may be represented by the points of a quadric variety V_3^2, the intersection of a four-flat with a V_4^2 in a space of five dimensions.

Hence we have three associated systems, viz.: nul lines of a force system in three dimensions, the lines of a linear complex, and the points of a V_3^2 in a space S_5.

This paper cites a few examples wherein a theorem proved for one system admits of immediate interpretation in the other two. It also proposes to illustrate the advantages and added interest derived from a study of each system in conjunction with the other two.

28. Infinite series involving confluent hypergeometric functions.

N. A. SHASTRI, Amraoti.

The series of the type

$$\Sigma\, a_r N_{b_r,\, c_r}(x) t^r$$

has been discussed, where the parameters b_r and c_r are of the type

$$b_r = k+\rho\nu+\alpha r \qquad c_r = m+\sigma\nu+\beta r,$$

and a_r has one of the following forms:—

(i) $\dfrac{(r+\mu)^s\,\Gamma(2\nu+r)}{r\,!}$ for (a) $s=1$, $\mu=\nu$ (b) $s=1=\mu$ (c) $s=2$, $\mu=1$.

(ii) $\dfrac{(-)^{r-1}}{(2r-1)\,!}$, $\dfrac{(-)^r(2r+1)}{(2r)\,!}$ and $\dfrac{(-)^{r-1}\,2r}{(2r-1)\,!}$.

$N_{k_i}\, m$ being Whittaker's function.

The conditions under which the series is uniformly convergent are discussed. A theorem regarding the summation of the series is proved, and methods of operational calculus are used to obtain the sum of the series.

29. Large scale Sample Surveys.

P. C. MAHALANOBIS, Calcutta.

1. Three types of problems emerged directly or indirectly out of certain large scale Sample Surveys which had been entrusted to the Indian Statistical Institute and conducted by it during the period of 1937–41. The problems relate to the formulation of a proper sampling design for estimating with maximum precision for a given cost (i) the

proportion of land under a particular crop or crops, (ii) the yield per unit area of a particular crop, and (iii) the geographical distribution of the crop over a particular area in respect of both proportion of land under the crop and yield per acre. In the technical language used here, the problems are those of (i) the area census, (ii) the yield census, and (iii) mapping surveys. The enquiries referred to the Statistical Institute were mostly concerned with (i) and (ii), the problem (iii) being suggested while work on (i) and (ii) was in progress. The experience of the last few years has led to the evolution of a nearly complete solution of the problem (i) both in the abstract as well as in the concrete, and a partial solution of (ii) mostly in the abstract, both of which are discussed in the present paper. With regard to (iii) certain tentative ideas have been reached and further work is in progress but the results have not been included in this paper, being considered hardly worthwhile discussing publicly at the present stage.

2. The theoretical approach to the solution of the fundamental problem is made in the following way:—

Suppose the whole area under investigation is cut up into a number of basic units each with a particular value of the variate in question. With any suitable grouping of the values we have an abstract frequency distribution of the variate corresponding to which there might be a determinate number of space distributions of which the observed space distribution is but one: (*a*) For a given abstract frequency distribution of the variate, and (*b*) under any suitable criterion (of which a number are discussed in the present paper), most of the associated space distributions would conform more or less to a pattern, the nature of the pattern depending on (*a*) and (*b*), while comparatively few would depart from the pattern. The conforming types are conveniently called random space distribution, while non-conforming ones are called non-random types.

3. Consider in particular a criterion which can be explained as follows:—Suppose we take a number n_0 of basic units in a specified configuration after a compact block (which we technically call a 'grid') and n such grids taken at random over the field, the whole set of $n \times n_0$ units constituting a certain sample which is supposed to estimate (i) the proportion of land under a crop or (ii) the yield per unit area of that crop. The precision of the estimate thus reached will be proportional to $n \times n_0$ for most space distributions (associated with any given abstract distribution) but will be a different function of n and n_0 for some space distributions including those usually observed in nature, in particular for those we have already studied. The cost of survey which involves journey from grid to grid and certain operations on the grid itself once it is reached, and includes other items of work, would again ultimately be a function of these n and n_0. The way in which the cost and the precision depend on n and n_0 being supposed to be known we can easily devise a suitable design of survey which will secure maximum precision for a given cost. This is for an area which is not very heterogeneous in respect of the variate in question. If the area were otherwise, we try to cut it up into a number of more or less homogeneous zones, in which case the theory yields by way of proper design different n and n_0 for the different zones. While this is generally applicable to problems of both types (i) and (ii), we have, however, for the type (ii) on grounds of economy a more complicated design which consists in the whole area being cut up into a number of zones, each into a number of suitable subzones, each subzone being further sub-divided and random choice being made of a few zones, then a few subzones in the zones already chosen, and so on till we come to the last stage where a few 'grids' are chosen at random. Depending on the nature of the field there might be appropriate designs coming out more complicated than this. Finally a proper plan envisages the whole work being spread over a number of years with an increasing scale of operations from year to year. The work of the first year is supposed to give us just enough information to enable a proper plan of work being made for the

next year and so on till we get to end of the available period when operations are to be planned on a grand scale with a view to obtaining the fullest possible information on the points under enquiry.

4. These abstract principles are also illustrated by suitable numerical and algebraic examples drawn from some of the surveys we have actually conducted, in particular the Sampling Survey of area under Jute in Bengal, work on which was spread over the period of 1937–42.

Section II, Physics.

16. *f*-values of potassium atom.

JATINDRA NATH, Lahore.

The apparatus to observe absorption photographically in potassium vapour is described. High power discharge in hydrogen gas gave continuous background for most of the lines. An iron tube 3 metres long with quartz windows on water-cooled ends was heated and the temperature was measured accurately by iron constantan couples at three places.

Photographs were taken with a large dispersion quartz spectrograph. A rotating wire-gauze-type device was arranged to calibrate the plate. Each plate containing two or three absorption spectra in addition to many calibration spectra was microphotometered and *f*-values calculated.

Continuous absorption at the limit of the series was observed to be very small and in this respect results are similar to those of Bott for sodium vapour.

17. Constitution of acetic acid-water mixture.

KANWAL SINGH, Lahore.

Investigations on Raman effect of acetic acid in water have been variously interpreted by some authors as indicating associations through hydrogen bond while others maintain that polymerization takes place.

Water and alcohols which are highly associated liquids have been studied in mixture by ultrasonics and it is shown that the individual association of each liquid is broken up in the mixture giving simpler molecules. By analogy, it is suggested that acetic acid-water mixture also gives rise to simpler molecules and no bond is present. Experimental evidence, by ultrasonic methods, in support of this is presented.

Section IV, Geology and Geography.

27. Re-classification of the Eocene of N.-W. India.

E. T. VACHELL, Digboi.

Certain controversial matters which have arisen regarding the correlation of portions of the Eocene of North-West India were discussed, and it was explained that increasing knowledge has shown that the original classification of the Khirthar and Laki Series no longer provides a satisfactory basis for correlational purposes and that a radical revision has become necessary. A co-operative plan for carrying out this revision was suggested, and it was advocated that meanwhile it would be advisable to refrain from adding to existing confusion by publishing further controversial matter.

Section VI, Zoology and Entomology.

66. The relative importance of different species of sugarcane borers and seasonal incidence in Hyderabad State.

MOHAMED SULAIMAN VARASI, Hyderabad-Deccan.

It was generally noticed that the attack of moth borers start from the month of February, reaches its climax in the months of April and May,

and declines thereafter. The highest attack is that of the stem borer

Section III, Chemistry.

56. Hysteresis in the sorption of water on casein, egg-albumin and gelatin.

G. N. SUBBA RAO, K. SUBBA RAO *and* BASRUR SANJIVA RAO, Bangalore.

By employing a McBain-Bakr quartz fibre spring balance a series of sorption and desorption of water vapour at 30°C. on casein, egg-albumin, denatured casein and denatured egg-albumin have been conducted and in these systems there is either no hysteresis loop or the loop initially exhibited disappears on successive sorption and desorption. These results indicate that the disappearance of the hysteresis effect is dependent on the swelling property of absorbents in the solvating liquids.

On denaturation of casein and egg-albumin, the sorptive capacities for water are lower than those of normal casein and albumin. These results indicate a decrease in hydrophilic character on denaturation.

57. Experiments towards the synthesis of Spilanthol.

P. C. MITTER *and* DAMBARUDHAR GOGOI, Calcutta.

When ethyl ω-carbethoxy-Δ^{α}-valeryl-*n*-propylacetoacetate (*Proc. Ind. Sc. Cong.*, 1942, Pt. III, 82) is hydrolysed with alcoholic potash at room temperature it gives an acid which was supposed to be 6-keto-Δ^{4}-decenoic acid. On further examination, it was found that rupture had taken place next to the double bond and that dihydromuconic acid had been largely regenerated in the *trans*-form (m.p. 192°). Attempt at the synthesis of the keto-acid by Blaise-Maire reaction between ω-carbethoxy-Δ^{α}-valeryl chloride and *n*-butyl iodide gave the butyl ester instead of the ketone as the major fraction. Next, attempt was made to synthesise $\Delta^{4, 6}$-decadienic acid direct by means of Grignard reaction between β-aldehydo-propionic ester and Δ^{β}-hexylene bromide. To obtain the second component butyraldehyde was first condensed with acetylene which, however, probably gave a dimolar product. Next, Δ^{2}-hexenoyl chloride (b.p. 80-83°/30 mm.) was reduced to the corresponding aldehyde by means of quinoline hydrocyanide. The aldehyde boiled at 150-160°. The semicarbazone melts at 170-171°. The aldehyde was reduced to the alcohol by means of aluminium *iso*propoxide. It boils at 80–85°/20 mm. The alcohol was converted into hexylene bromide with PBr_3 in the cold, b.p. 70–73°/30 mm.

the borers' attack and had a marked influence over the incidence (borers' attack).

Temperature.—The minimum temperature in which the borers keep up with their activities was 65° (below normal) in the months of July, August and September for Nizamabad District.

The minimum temperature for retarding the borers' activities was 48° (below normal) in the months of October, November and December, for Nizamabad District. That is to say the incidence (borers' attack) comes to almost nil at this temperature.

68. Life history of *Sesamia uniformis* Dudgn. and the larval parasites.

MOHAMED SULAIMAN VARASI, Hyderabad-Deccan.

In the H.E.H. The Nizam's Dominions sugarcane cultivation is very much concentrated in Bodhan (in Nizamabad District, where there is Nizam's Sugar Factory). Bodhan is situated at a distance of 115 miles from Hyderabad City. At Pandoo Farm (Nizam Sugar Factory area), Bodhan, borers of *Sesamia Sp.* on sugarcane were collected. Two of them were parasitized in the larval stages by two different parasites and others were reared up to the adult stages.

Injury done to the sugarcane crop by this borer is generally confined to the marginal portion of the field, occasionally it is found deep inside the fields and if the jowar or maize is near about the sugarcane fields, the borer may be found all over the field. They may bore into the side of the stem and burrow upward, destroying the heart of the plant, while outer leaves remain healthy or they may bore near the top of the stem and work downward. Holes with moist castings are found in the sides of the canes. It is seen that mostly young crop is attacked, showing 'dead heart'. So far the borer is observed here on sugarcane, maize and jowar. It is distributed generally, throughout the Nizams' State, wherever jowar, maize and sugarcane are grown. The life history was studied in the month of September, 1942. It was found that under laboratory conditions eggs hatched in seven to ten days, pupation took place in twenty to thirty days. The adult emerged in between nine and twelve days.

A larva of *Sesamia uniformis* Dudgn. was parasitized by *Diplerans techinida*; an account and biology of it is discussed in the paper. Another larva was parasitized by some unidentified small flies. The larva was completely eaten up except the chitenous head and prothoracic shield. A number of amber coloured very active adults measuring 2 mm. long came out on the 15th day after parasitization.

69. Life history and control of diamond back moth (*Plutella maculipennis.* C) in Bodhan, Deccan.

MOHAMED SULAIMAN VARASI, Hyderabad-Deccan.

Eggs hatched in 5 days, pupa after 10 days and the moth emerged in 5 days. The total number of days for the completion of the life history in the month of September, 1942, was 20. The control measures are as follows:—

(1) *Hand picking.*—The plants that are liable to be attacked should be examined at least once every seven to ten days and the eggs, larvae, etc. should be destroyed at once.

(2) *Spraying.*—Lead arsenate solution in the following proportion should be applied:—

Lead arsenate	4½ lbs.
Water	100 gallons.
Soap	5 lbs.

The cabbage plants form their leaves from inside and hence there is less danger of poisoning, but to be on the safe side insecticides like pyrethrum and Derris should be used.

Pyrethrum is non-poisonous and particularly effective for the young caterpillars. Insecticides made from Derris roots and from allied tropical plants contain various chemical substances toxic to insects, the best known being rotenone, a very powerful insecticide.

Derris powder	¾ oz.
Soap	½ to 1 lb.
Water	10 gallons.

The dust is not effective against the larger larvae.

Soap solution spraying also gives good results. Plants should be sprayed with soap solution thoroughly: Soap—2 oz. and Water—1 gallon.

70. General control measures for household insects.

MOHAMED SULAIMAN VARASI, Hyderabad-Deccan.

House flies, mosquitos, bed bugs, fleas, cockroaches, silver fish, ants, cloth moths and carpet beetles, are some of the more important insect species commonly found infesting dwellings. In combating household insects there are various insecticides worth considering, though too much emphasis cannot be given on any of those, which could retard or prevent the development of infestations of these pests. Insects that occur in the houses are of too manifold nature; some of them attack human beings and are the agents for the dissemination of diseases, others attack clothing and household furnishings causing sometimes serious damages. Still others which infest the foodstuffs render them useless for human consumption or else pollute them with bacteria and other organisms harmful for human life. Insects also attack our house plants. The purpose of the paper is just to provide the people with necessary information to control the household pests which are in some houses a great nuisance.

Section IX, Agricultural Sciences.

37. Importance of boron in agriculture.

MOHAMED SULAIMAN VARASI, Hyderabad-Deccan.

Boron, which is one of the minor elements, has been determined to be an essential element for plant growth. A deficiency of boron reacts by producing various physiological disorders in plants and inducing deficiency diseases. Boron-deficiency troubles can be eliminated by the application of borax or boric acid to the soils, 8·8 lbs. of borax or 5·8 lbs. of boric acid being required to yield one pound of boron. Boron-deficiency occurs in soils as a result of their being under continuous cultivation for a long period and being subjected to a very intensive cropping and rotation programme. More boron is available in a low-lime soil than in a high-lime soil (where it is practically unavailable). A high-lime soil is subject to an incidence of boron-deficiency diseases. Soils of pH over 6·5 encourage boron-deficiency diseases. A high moisture content in the soils reduces the liability to boron-deficiency diseases, which seems to indicate that high moisture content is capable of increasing boron availability. If present in excess or in unrequired quantities, boron may be toxic to many plants. Turnips are tolerant to a high concentration of boron, whereas cotton requires less boron than other plants. Boron has a direct bearing on the nitrogen metabolism of the cotton plant.

The paper also gives a description of boron-deficiency diseases in different crops.

38. Effect of aeration and de-aeration on plant-life as observed by a farmer.

BISHAN MANSINGH, Fatehpur.

Practical farming experience shows that hoeing and weeding at proper intervals has a decidedly beneficial effect on crops and promotes their maximum growth and yield. These operations benefit the crops not only by the prevention of the competition of weeds for the available plant-food and moisture in the soil, but also by providing aeration to their roots.

An undergrowth of weeds and grass seriously affects the yields of fruit trees like Citrus. It brings about the fall of young and unripe fruits, and reduces the volume and quality of the yields, in addition to

favouring die-back. In the case of two old and unproductive mango trees, the author was able to give them a new lease of life and cause them to put forth abundant fruits by having the base of the trees wooded and ploughed up and by having the soil beneath opened up by trenching.

While aeration is helpful to plant-life, de-aeration causes the plants to die. The author has been able to employ this principle to kill out various undesirable plants by denying their roots access to air either by flooding or by smothering their roots by favouring grass growth.

Section X, Physiology.

33. Chromatographic adsorption method for the estimation of provitamin A content of foodstuffs.

G. B. RAMASARMA, D. N. HAKIM *and* S. D. RAO, Bangalore.

A critical examination has shown that the petrol-methanol phase partition for the separation of carotene from xanthophyll, which is a common feature of all the existing methods, is unsatisfactory as certain coloured but biologically inactive degradation products also remain in the epiphasic layer and consequently estimated as carotene. Such errors are likely to occur especially in the case of stored foodstuffs and in a few cases the values reported by earlier workers appear to be due entirely to the presence of such non-carotene pigments. As a result of a search for an adsorbent suitable for the routine determination of the provitamin A content by the chromatographic adsorption technique, dicalcium phosphate prepared according to Moore (*Ind. Eng. Chem., Anal. Ed.*, 1940, **12**, 726) has been found to be promising. Further, an additional advantage of the adsorption method is that the preliminary saponification of the pigment extract for breaking up the xanthophyll esters can be safely omitted in a majority of cases. The method has been tested in a number of details, conditions for obtaining satisfactory results have been worked out and limitations are defined. Estimation of carotene present in different Indian foods by chromatographic adsorption technique is under way.

34. Distribution of phosphorus in mammalian brains.

NRIPENDRA LAL LAHIRY, Bangalore.

The nature and amount of various types of phosphorus compounds present in different brains of mammals possessing varying body weights have been investigated. The dry matter of the brain tissues of some of the important vertebrates (ox, he-goat, dog, rabbit and rat) contain about 1% of phosphorus. The trichloroacetic acid soluble phosphorus was fractionated into inorganic ortho-phosphate, labile esters such as adenyl-pyro-phosphate, resistant esters such as hexo-phosphate, and phosphogens such as creatine phosphate. About 17% of the total phosphorus of the wet tissue is extractable by trichloroacetic acid in almost all brains. The results indicate a striking similarity in all the brains examined.

Section XI, Psychology and Educational Science.

31. Manifestations of oral fixation in poetry.

RAFI-UZ-ZAMAN KHAN, Lahore.

Urdu and Persian poets like Josh, Momin, Sauda, Quqnus and Qaani are drawn in with a view to examining Birk's remarks that poets who take pleasure in rhyming show definite oral fixations and their neuroses represent oral regressions or failures in oral sublimation.

2. ERRATA AND ADDENDA

[REFER TO PART III OF THE PROCEEDINGS CONTAINING ABSTRACTS]

Section of Botany.

(*1*) Paper No. 6 on page 47: Read *Penicillariae* instead of *Pennicillariae*, both in the title and in the second line of the text.

(*2*) Paper No. 7 on page 47: *Correct* the spelling of *Penicillariae* in second and third lines, which word has been wrongly printed as indicated in (*1*).

(*3*) Paper No. 30 on page 54: *Correct* the mistake as above in second and fifth lines.

Section of Zoology and Entomology.

[The arrangement of the sub-sections under this section was not in order and Dr. B. N. Chopra, President of the Section, is not responsible for the mistaken arrangement.]

(*1*) Paper No. 24 on page 64: thirteenth line, *omit* '*Herpele*' and on fourteenth line *insert* '*Herpele*' after *Ichthyophis*.

(*2*) Paper No. 26 on page 64: ninth line, *delete* 'not' between the words 'was' and 'noticed'. The sentence will read: A lamina orbitonasalis was noticed.

3. DISCUSSIONS

I. TEACHING OF STATISTICS.

(*Section of Mathematics and Statistics, in co-operation with Indian Statistical Conference.*)

PROF. F. W. LEVI, Calcutta, presided.

1. PROF. B. SARKAR, Calcutta.

Every university should have a professor of statistics to impart higher teaching in statistics. Statistics being one of the most essential tools of modern scientific investigation, can it be taught without higher mathematics? Can it be so managed that the highest form of mathematics required is simple arithmetic? I believe it is possible. In the Government departments statistics is being collected and handled by persons who are not strong in mathematics. Ordinary people are accustomed to think in terms of non-mathematical statistics. In politics, labour problems, in Economics, in Social Anthropology one cannot do without statistics. Their very progress depends on it. So, if you can manage to teach statistics, as I have asked you to do, without higher mathematics, it will be great help not only to general intelligence, but by facilitating greater appreciation of the ability of statistical methods, it will help you to find greater demand for trained statisticians.

2. DR. H. SINHA, Calcutta.

The Indian Statistical Institute took the initiative in the teaching of statistics by holding the first examination in 1938 and by starting

classes in 1939 to teach statistics. The Calcutta University then took up the task and started for the first time in India post-graduate classes in statistics and is going to hold the first examination this year. Formerly they had statistical courses as subordinate subject in their other courses: Economics, Commerce, Pure Mathematics and Applied Mathematics. In this way statistics was cut up and divided. The division of statistics had produced many evils like unscientific and superficial nature of the non-mathematical statistics, slurring over of difficulties, etc. Also, on the other hand, disproportionate stress has been laid on Mathematics. For teaching of statistics, no cut-and-dry method can be framed. The system of teaching should be highly elastic to suit the needs of diverse interests.

3. MR. R. C. BOSE, Calcutta.

Statistics should be taught in the school, in the Intermediate and B.A. classes as Prof. Sarkar has said. Definite numerical bias is to be given from the very beginning to elementary mathematics, for the harder core of mathematics is only for a few, but the majority learn it to use it; mathematics has become the language of science. In reply to Prof. Sarkar's proposal to divorce statistics from mathematics except of the most rudimentary form I can say that it is time that the ordinary people should learn sufficient mathematics to follow modern statistics of which it is the base. It is seen that mathematics has invaded all the branches of social sciences to which Prof. Sarkar has alluded and so it is high time for investigators in those branches to learn it.

My experience as examiner of mathematics in the Matriculation and in the Intermediate Examinations teaches me that the fundamental defect of teaching of elementary mathematics is that it is abstract and mechanical. Much time is wasted in doing complicated problems. Students know how to do mechanically sums by the method of rule of three, but these do not give them proper insight. They must be given live data. They can be taught the drawing of histograms, calculation of means, standard deviations, etc.

4. DR. C. CHANDRA SEKHAR, Calcutta.

The gap between theoretical knowledge and its application is wide. The Indian Statistical Institute is the only organized place where healthy contact between the analytic statistician and people engaged in handling live problems is possible. Vital statistics is just one of the applied statistics. So here two questions arise: whether a medical man should learn some statistics and then interpret the data or a mathematical statistician should acquire some medical knowledge. According to me the latter alternative is more suitable. Interpretation should be left in the hands of the mathematical statistician.

5. MR. Y. S. TU, Calcutta.

I shall try to compare the teaching of statistics in India with that in China.—(i) In China statistics is taught both in the undergraduate and in the post-graduate classes. But here I see that it is only taught in the post-graduate classes. (ii) In China there is no independent department of statistics as in Calcutta. But it is taught in the various departments along with other subjects. (iii) The course is not so specialized as in Calcutta. It is of elementary character.

In China some elementary statistics is taught in the middle school as an optional subject. The mode of teaching of Prof. P. L. Hsu of the National University of Peking in the Dept. of Mathematics is as follows: For one year he teaches the theory of Matrices, Quadratic form, Lebesgue integral, Probability. After this he begins the theory of advanced statistics.

6. PROF. F. W. LEVI, Calcutta.

The general impression seems to be that statistics is being pestered with mathematics. I know that the unpopularity of mathematics is because it is not taught in the proper way. In the matter of teaching we, mathematicians, are hampered by traditional modes; whereas your chief difficulty is having no tradition at all. The traditional difficulties in mathematics can be observed by looking at the committees which are often organized for the reform of mathematical teaching. There are many things to be eliminated from mathematics courses.

Statistics is Applied Mathematics and training in mathematics is essential for proper appreciation of the subject. This training could well be started in the schools. But here an interesting difficulty crops up. The schools consider that they already have too much of things mathematical and that they should not be bothered with anything more. And the colleges refuse to make any changes in their course unless necessary changes are previously undertaken in the schools. What is required is to sacrifice sectarian interests and to evolve a programme which will be most suitable from the national point of view.

7. PROF. P. C. MAHALANOBIS, Calcutta.

Elementary statistics may be introduced in schools by giving a numerical bias to the arithmetic courses already followed. Problems of Probability involving permutations and combinations can be easily taken up. There is great need for a text-book embodying the course of statistics we want to teach in the schools. It will be a great service if the statisticians present here undertake the preparation of one.

II. RECENT PROGRESS IN COSMIC RAY PHYSICS.

(*Section of Physics.*)

PROF. M. N. SAHA, Calcutta, presided.

1. MR. S. K. CHAKRABARTY, Calcutta.

Atmospheric absorption curves.

One of the fundamental problems of the present time, on which largely depends further progress in cosmic ray physics, is the determination of the nature and source of the primary cosmic rays. From the well-known latitude effect and the intensity measurements at different altitudes it is clear that the primary must contain some charged particles. It is therefore possible that either protons or electrons or both must exist in the primary. The existence of mesons, however, is being ruled out from a consideration of its instability. The atmospheric absorption curves were measured by several authors and at various latitudes. The previous measurement of Bowen, Millikan and Neher (1938) was made with the help of electroscopes or single counters which respond to rays reaching them from all directions instead of merely from the vertical. Even with Gross-transformation these data cannot be used for any fine structure analysis of the primary. To overcome this difficulty, Neher and Pickering (1942) have, however, used two counters as a cosmic-ray telescope to record the radiation coming from a definite direction.

With a view to explaining these absorption curves in terms of primary electrons or positrons, two different hypotheses as to the nature of the primary energy spectra were assumed, viz.: (*a*) that the primary has a continuous energy spectrum and the number of particles having energy E varies as $E^{-2\cdot 87}$, and (*b*) that only discrete sets of isoenergetic particles produced through the annihilation of different atoms exist, which are found in abundance in the interstellar space.

These primary electrons or positrons on passing through the atmosphere will produce cascades. Using the accurate results of the cascade theory and above hypothesis as to the primary energy spectrum, the theoretical absorption curve for any latitude can be obtained.

The measurements of Neher and Pickering at Agra and Bangalore, however, put a strong evidence in support of the hypothesis (*b*), but this cannot explain the observed existence of some of the most energetic rays, which are known to be more than a thousand times the mass of the heaviest known atom. The theoretical Agra-Peshawar difference curves on both the hypotheses practically coincide and so cannot be used for distinguishing either of the two hypotheses. The theoretical curve when compared with the observed Agra-Peshawar difference curve shows that the observed rate of rise of ionization near the top of the atmosphere is more rapid than the theoretical estimates, which may possibly be due to the use of counters instead of electroscopes for observation. As the altitude increases, groups of particles must become increasingly prevalent, and these register but once in the counter and thereby give an estimate much lower than the actual intensity. To compare more accurately in these regions, counter-controlled electroscopes or any other device which will record the ***true ionization produced by vertical rays*** should be used for observation.

At large depths below the top of the atmosphere the actual ionization is observed to be much more than can be explained by the cascade theory. This difference and also the observed sea-level latitude effect make it necessary to postulate that the primary should contain protons. In that case it will also be necessary to admit the existence of hitherto unknown process which allows a complete absorption of protons in the very upper layers of the atmosphere and a consequent production of mesons, electrons or γ-rays. Recent work by Heitler and others, however, suggests that some such phenomena may be possible from the theoretical standpoint. Whether they will also explain the observed absorption curves remains as yet to be seen.

The foregoing account shows that protons must exist in the primary cosmic rays, and also suggests that mesons, at least in parts, are produced by protons. There may, however, be several other primaries for the production of mesons. Whether electrons do exist at all in the primary cosmic rays can only be ascertained by further measurements of the atmospheric absorption curves at closer intervals.

2. Dr. R. C. Majumdar, Calcutta.

Production of mesons.

It was first shown by Millikan, Bowen and Neher from the high altitude cosmic-ray measurements that the mesons which are generally found at sea-level are secondaries produced by the soft component of the cosmic radiation in the upper atmosphere. The counter experiments of Schein and Wilson at high altitudes brought forth further evidence that the mesons were produced by non-ionizing radiation, presumably photons high up in the atmosphere above 20,000 ft. The experimental evidences on the production of multiple mesons by photons are also accumulating in recent years. It may be, therefore, of some interest to study quantitatively the theoretical possibilities of the production of mesons, single and multiple, by the photons. The single meson is produced by the photon in matter in nuclear interaction as a two-stage process. The neutron (proton) is first transformed into a proton (neutron) with the virtual emission of a negative (positive) meson, which then absorbs the photon of requisite high energy and becomes free. The production of multiple mesons has presented, however, a great difficulty. It was first suggested by Heisenberg, from the fact that the cross-section of the meson production increases with energy at energies large compared

with the rest energy of the incident particle, that a number of meson secondaries can be produced in nuclear interaction in one act (explosion). But the recent work of Bhabha has shown that the increase of the cross-section with energy at high energy is spurious and is due to the neglect of the radiation damping, the effect of which becomes sufficiently large in the energy range under consideration to reduce the cross-section to vary as the inverse power of energy. Following the work of Heitler and Wilson it is still possible, even if we take into account of the radiation damping, to find an energy region where the multiple creation of mesons is more probable than that of the single meson. The quantitative calculation has been carried out for the production of two mesons by a photon. It has been recently suggested by Johnson and by Schein, Jesse and Wollan from their observations that the mesons are produced in multiples in the high atmosphere by protons. The production of mesons by protons is also a two-stage process; the meson is first created in the virtual state through neutron-proton transition, which is then knocked out as a result of proton-meson collision.

3. Dr. S. C. Sirkar, Calcutta.

On the existence of neutral mesons in cosmic rays.

It was pointed out by Rossi, Janossy, Rochester and Bound that the increase in the number of coincidences observed at sea-level by previous workers by shifting an absorber from its position between the counters of a vertical coincidence counter telescope to the top of the telescope was due to some side showers. The investigation was repeated at Calcutta by Sirkar and Ghosh who used an anticoincidence circuit and observed that besides the effect due to side showers there was an increase of 5% of the total vertical meson intensity with the shift of the absorber mentioned above. This increase diminished to about 2% when additional lead absorbers, about 20% thick, were placed permanently on the top of the counter telescope. This latter increase was attributed to the production of mesons in the absorber by neutral particles or 'neutrettos' present in cosmic rays. In order to investigate further the nature of these neutral particles the investigation was repeated more carefully by Sirkar and Bhattacharyya, who made their counter telescope vertical as well as inclined to the vertical. It was observed that the increase in the number of coincidences with the shift of the absorber in the case of the vertical telescope and with a lead absorber 10 cm. thick on the top of the telescope was 1·4% of the vertical meson intensity. When the telescope was inclined to the vertical making a zenith angle of 30° to the east, and the lead absorber, 10 cm. thick, was placed permanently above the telescope, the said increase in the number of coincidence with the shift of the absorber was again about 1·4% of the total meson intensity in the said inclined direction. The intensity of mesons in the inclined direction was less than that in the vertical direction owing to the instability of the mesons. Since the intensity of the neutral particles producing mesons in the lead absorber with respect to that of the mesons was observed to be the same, both in the vertical and the inclined direction, it was concluded that these neutral particles are unstable. The absorption co-efficient of these particles was observed to be of the same order as that of the meson. This gives the life of the neutral particles of the same order as that of the meson.

4. Dr. D. M. Bose, Calcutta.

Photographic plate method of investigation.

The speaker gave a short account of the photographic plate method of estimating the mass of the cosmic-ray particles responsible for the production of heavy ionization tracks in photographic plate emulsions exposed at high altitudes like Darjeeling (7,000 ft.), Sandakphu (12,000 ft.)

and Phari Jong (14,500 ft.). The method is based upon (i) sorting the particles into different groups according to the mean grain spacing along their tracks, (ii) finding the kinetic energies of proton tracks which produce the same mean grain spacings on the photographic emulsion—the assumption being that both the cosmic particles and protons are singly charged and therefore the m.g.s. along their tracks will be the same if they both start with the same initial velocities, (iii) determining the mean kinetic energy of each group of the cosmic ray particles from the mean scattering suffered by their tracks in the photographic emulsion.

It has been found by the speaker and Miss Bibha Choudhuri that the average mass of the ionizing particles acting on the photographic plates kept at Sandakphu under air, (*a*) for single tracks is 217 ± 30, (*b*) for pair tracks is 186·0; (*c*) for tracks in plates kept under 20 cm. of water is $336 \pm 19{\cdot}5$, (*d*) for plates kept under different thicknesses of lead 0·5 cm. to 5 cm., the mass varies from about 300 under 0·5 cm. Pb, to about 550 under 1·5 cm. Pb and it again comes down to about 300 under 5 cm. Pb. The conclusions drawn from these results are that under air (for which the critical energy for cascade production is $1{\cdot}03 \times 10^8$ eV) a very large portion of the ionizing particles whose tracks are recorded in the photographic plates consists of mesotrons and not protons. Under water and also under paraffin there is a large reduction of the tracks recorded on the plates, whose average mass is thereby increased—indicating that high energy neutrons (also probably protons) are responsible for the production of starlike tracks on the plates. By collision with hydrogenous matter, their velocities are considerably diminished and secondary protons of low velocity ($\sim 10^6$ eV) are produced which can affect the photographic plates. Under different thicknesses of lead a multiplication effect is observed whose maximum lies in the region of 1·5 cm. Pb (critical energy 7×10^6 eV), apparently coinciding with the first maximum of Rossi's curve. It is further noticed that the average mass of the particles is largest under 1·5 cm. lead—showing that the soft component of the cosmic ray is responsible for the multiplication effect due to nuclear evaporation, which in the case of the tracks recorded on the photographic emulsion consists of protons. From the value of the average mass of the ionizing particles, the ratio of the protons to mesotrons at the maximum is about one to five.

On the assumption that the multiple tracks observed on photographic plates are all due to mesotrons (and not due to a mixture of mesotrons with heavier particles), the energy spectrum of the particles under air and under lead has been determined. It is found that (i) in the plate kept at Sandakphu under air, and under water, the distribution starts with a maximum of $n = 1$; from $n = 2$ to $n = 5$, the number of particles remains more or less the same and from $n = 6$, the number falls off rapidly. Under different thicknesses of lead varying from 0·5 to 5·0 cm., there is a maximum at $n = 1$, a sharp minimum at $n = 2$, a secondary maximum at $n = 3$, and then there is a monotonous falling off. Assuming with Heisenberg that a mesotron wave packet is produced by the impact of a high energy neutron (proton) with a neucleon (i.e. nuclear neutron or proton), a part of the latter's virtual mesotron field is radiated away as a wave packet of energy $\epsilon_0 > 10^8$ eV; this wave packet can materialize into a multiple emission of n mesotron particles such that $\epsilon_0 = nx + \sum_1^n \epsilon$ where $x =$ mesotron mass, ϵ is the K.E. of the mesotron particles; for $n = 1$, a single particle is emitted with the largest kinetic energy $\epsilon = \epsilon_0 - x$. Blackett has determined the low energy spectra of penetrating cosmic-ray particles in a Wilson chamber, under different thicknesses of lead varying from 0·3 to 5 cm. A comparison of his energy-distribution spectra with $n = 1$, with ours for which n is a maximum, shows a very significant similarity in distribution, which indicates that there is some experimental support for Heisenberg's hypothesis of the materialization of mesotron wave

packet into multiples with different number of particles. It is proposed that with the return to normal conditions, the energy spectrum of the heavy ionizing particles with a Wilson chamber and a photographic plate will be taken simultaneously at Darjeeling, to further test Heisenberg's theory.

5. Dr. N. Das Gupta, Calcutta.

Decay of mesons.

The radioactive decay of mesons has been confirmed by our experiments carried out at Calcutta and Darjeeling (height 2·2 km., 16°N. geomagnetic latitude). The vertical intensity of mesons at Calcutta has been compared with that at Darjeeling under additional lead blocks equivalent to the mass of air between the two stations. This would compensate for the extra mass traversed by mesons reaching the lower station. We have also compared the vertical intensity at Darjeeling under 44 cms. of lead with that at an inclined direction of 40° to the zenith. Under this condition the mass traversed by the vertical and inclined rays is the same. In both these experiments although the mass traversed by the cosmic-ray mesons were exactly identical, the actual lengths of path travelled by them were different. Hence from a comparison of intensities evidence of decay along the longer track could be established. From these as well as from the ratio of the soft to the hard component at the two stations, the life of the meson is deduced to be about $2{\cdot}0 \times 10^{-6}$ secs.

III. MATHEMATICAL THEORY OF ELEMENTARY PARTICLES AND THEIR INTERACTIONS.

(Section of Physics.)

Prof. M. N. Saha, Calcutta, presided.

1. Mr. S. K. Chakrabarty, Calcutta.

It is at the present time more or less established that meson can be considered as a fundamental particle having a charge e and a mass m nearly 170 times that of electron. Some doubts, however, exist about the spin of the mesons and it is apparent from theoretical considerations that a measurement of the large bursts which are produced by high energy mesons, when compared with their theoretical estimates will give definite indications about the spin of the mesons, which is at present one of the fundamental problems of nuclear physics.

The large burst is produced by a meson which either knocks out a very fast secondary electron or radiates a high energy quantum, both of which ultimately produce large showers by the usual cascade process. Using the differential effective cross-sections for the production by a meson of a secondary electron or a quantum, as given by various authors for different spins of the mesons, viz. 0, $\frac{1}{2}$, or 1, and also the expression for the average number of particles produced in a cascade shower given by us (Bhabha and Chakrabarty, 1942) the probability of getting *more than N* particles under an infinitely thick layer of a material has been estimated. The only source of uncertainty in such calculations is the nature of fluctuations, for which a Poisson distribution has been assumed.

It appears that the probability $J_N(y_0)$ of getting *just N* particles below a thick layer produced by a high energy secondary particle or quantum of energy βe^{y_0}, produced by a meson anywhere within the material, can be given analytically by the following expression,

$$J_N(y_0) = 3{\cdot}21 t_m^{\frac{1}{2}} \cdot \frac{1}{2\pi i} \int_{\sigma - i\infty}^{\sigma + i\infty} \frac{\Gamma(z) N_m^{N-z}}{\Gamma(N+1)(N-z)^{\frac{1}{2}}}\, dz,$$

where N_m is the maximum number of particles produced in the cascade at a depth t_m, by a particle or quantum having energy βe^{y_0}. With such an expression it can now be easily shown that $J_N(y_0)$ tends to zero when $N_m<N$ and is finite when $N_m \geq N$, a behaviour, which was originally suggested by Bhabha (1938). This shows that the largest shower which occurs with any probability, produced by a meson of energy W contains N particles where

$$N = N_m(y_0) = 0{\cdot}169 \text{ exp. } y_0 \, . \, (y_0 - 1{\cdot}90)^{-\frac{1}{2}}$$

and

$$y_0 = \log (E_{0m}/\beta) \quad \text{or} \quad \log (W/\beta),$$

depending on whether the shower is produced through a knock-on process or a radiation process, E_{0m} being the maximum energy which can be communicated to an electron in a free collision by the meson.

It has been shown that in the calculations of the frequency of burst production, for small showers the knock-on process predominates while for large showers, say $N \geq 100$, the radiation process gives nearly the whole contribution. The experimental results of Schein and Gill (1939), when compared with these theoretical estimates show that mesons with spin 1 are only possible provided due consideration is made for the effect of radiation damping. The cases of spin 0 or $\frac{1}{2}$ give much lower value for the burst frequency. The reasons for getting results which are so much different from those of Christy and Kusaka (1941) and consequently leading to just an opposite conclusion are mainly (1) the difference in the form of the fluctuation assumed, (ii) the very rough approximation made by them for the average number of particles produced in a cascade, and also (iii) the neglect of the consideration of the effect of radiation damping for mesons of spin 1.

It is, therefore, clear that the frequency-size curve for large bursts provides evidence that the meson cannot have spin 0 or $\frac{1}{2}$. The case of spin 1 is a possibility or even a probability only when the effect of radiation damping is taken into consideration. The meson has, therefore, a spin of one unit in agreement with what is believed from nuclear considerations and the above discussions lend further support to the fact that the effect of radiation damping plays an important rôle in processes involving mesons.

[Other contributions were not received.]

IV. INTELLIGENT USE AND CONSERVATION OF INDIA'S COAL.

(Sections of Geology and Geography and Chemistry.)

Dr. P. Neogi, Calcutta, presided.

1. Dr. J. A. Dunn, Calcutta.

Much has been written in recent years on the subject of the use and conservation of coal resources in India. Because of its importance and the undoubted waste which still persists in the coal industry, suggestions of nationalization have been applied more frequently perhaps to this than to any other industry in this country.

The eradication of mistakes in mining and utilization of coals, so extravagant in the past and even to-day, is as urgent in India as in other countries, and there is the need for a controlled campaign directed towards the improvement of methods of mining, marketing and utilization of coal. Any improvements will contribute to the conservation of the limited reserves available in India, particularly of coking coals.

Under mining, the dominant interest is perhaps improvement in mining technique, leading to conservation of reserves and reduction of

losses by fire and collapse. The functions of the Sand Stowing Board are a step in the right direction. The granting of leases independent of zamindari boundaries is advisable, for zamindari boundaries are not necessarily the best advisable between mining properties. In addition, the controlled working of seams not only along the strike and down the dip, but also vertically according to a definite sequence is eminently desirable. This may not be possible now in the coalfields, such as Raniganj and Jharia, but it may be feasible in the more western fields. Such mining according to a controlled sequence would imply also a close control in the marketing of coal, and possibly even compulsion in the use of inferior grades for certain purposes.

The time has long past when we can afford to use only high grade coking coals for other than coke to be used for metallurgical purposes, yet vast quantities of our best metallurgical coking coals are still being wasted for steam raising purposes for which there are other coals equally suitable. Restrictions on the use of coking coals for other than metallurgical purposes are imperative, not in the future but immediately.

The necessity for a fuel research institute has long been recognized and it is hoped will soon be an accomplished fact. There is vast scope in such an institute for many lines of research, such as the beneficiation of lower grade coals, the mixing of coals to obtain good coking coals, and the utilization of by-product at present going to waste. Fuel research is so closely bound up with the minerals and metals industries that it will be a regrettable mistake if such an institute is not closely associated with a minerals and metals research institute.

Some more rational form of marketing coal is advisable. As a result of close competition, cheap and wasteful methods of mining are employed and the industry loses heavily. Co-operation in marketing, particularly amongst the smaller colliery owners, would be essential if a satisfactory price were to be maintained. Such co-operative marketing must involve control of the grades of coal produced, and might require Government supervision. One solution might be the standardization of coals and their sale at fixed prices through a central marketing body.

2. DR. P. NEOGI, Calcutta.

Dr. Neogi referred to the losses that the coal industry had been undergoing and stressed the ways out by means of chemical treatment of coal. On low temperature carbonization, coal yielded petrol, kerosene, Diesel and lubricating oils in the tar, and on high temperature carbonization, metallurgical coke, benzene hydrocarbons, carbolic acid, naphthalene, creosote and pitch. He deplored that whilst high temperature carbonization was practised to a very limited extent for metallurgical coke, low temperature carbonization was practically unknown in India. Enterprises are necessary for hydrogenation of coal or coke for artificial production of petrol and other fuel oils. He further pointed out the wasteful practice of manufacturing soft coke by stack-burning at the pit-heads whereby very valuable by-products are burnt off and lost to the country.

3. MR. N. N. CHATTERJEE, Calcutta.

A symposium on conservation of coal was arranged by the Geological, Mining and Metallurgical Society of India and the views on this topic contributed by several geologists, mining engineers and prominent men in the coal trade were published by the Society in 1937 (Bulletin No. 1). A reference should also be made to a publication by Sir Lewis Fermor in 1935 on this subject. The cry for conservation grew very insistent, especially on account of the huge loss of coal properties by fires and collapses coupled with the paucity of caking coal. Sir Lewis Fermor's Bulletin (official publication) on India's Coal Resources emphasized the point and the Government of India had to set up the Burrows Coal Committee to go into the whole question. But the questionnaire sent out by the Committee did not include any question on the conservation of

caking coal. I hold the view strongly that no solution of the question of conservation can be made without considering the question of proper utilization side by side with the question of provision of safety consistent with maximum extraction of coal.

The fact that India's reserves of coal of good quality is limited, calling for serious attention, was pronounced by the Geological Survey of India, and accordingly the urgent necessity for conservation was emphasized in a letter (No. M955, dated the 7th July, 1938) issued by the Government of India to all the Provincial Governments, from which an extract is given below:—

> 'The Government of India feel that statutory intervention for the purpose of conservation is desirable. The coal resources of the country represent an irreplaceable asset, and in the absence of revolutionary discoveries affecting the supply of energy, they are likely to remain an asset of great value. Recourse to inferior coal is possible for most purposes, but not without a loss of efficiency, and it is likely that long before the time at which the better coals are exhausted, their diminution and the increasing depth at which they must be won will operate to enhance the cost of industry. Further, when coal is lost, the waste is not confined to fuel; there are by-products of which future industrialists may make great use. Finally, the benefits of conservation are not likely to be deferred to a distant future.'

[The life of the reserves of good coal has been estimated to be less than hundred years, on the basis of the present output and method of extraction in vogue.]

Further interest in the subject was created during the last two sessions of the Indian Science Congress where discussions were held on subjects like 'Utilization of India's Mineral Resources' (*Proc. 28th Ind. Sc. Cong.*, Part IV, p. 59) and 'Mineral Policy for India' (*Proc. 29th Ind. Sc. Cong.*, Part IV, p. 61).

The process of conservation includes two important aspects, namely—

(i) Maximum extraction of all coal with utmost safety, and
(ii) Proper utilization of coal according to the existing knowledge.

On account of inefficient methods of coal extraction and lack of proper supervision of mining methods at several places, disasters in the shape of fires and collapses have resulted with permanent loss of coal. The working of the Coal Grading Board has also indirectly encouraged methods of extraction of particular sections of a seam in a manner which has been responsible either for loss of many other seams or for some of the sections being unworkable. This state of affairs in the Bengal coalfields is going on for a long time. The method of partial grading of a seam, leaving with the owners the option of the working of the full seam, should be immediately stopped. Even under present circumstances, by some process of more widespread stowing there would be much better results in extraction of coal with safety, and this would ultimately increase the life of the reserves of all qualities of coals. Some attempt has been made by the Government to introduce sand stowing in coal mines for maximum extraction and safety. But a careful scrutiny of the affairs show that by means of partial assistance the problem cannot be properly solved. It now seems necessary in the interest of conservation that more precautionary measures like compulsory stowing and full assistance should be introduced.

Regarding utilization, there should be systematic efforts to encourage efficient uses of coal and other minerals according to modern knowledge of purification, blending, etc. Simply the production and the consumption of minerals will not establish the country's mining industry and for the matter of that, all other industries on sound principle. Proper utilization of coal, which is country's irreplaceable asset, must be effected. It

appears to me that there are two courses left open for putting a stop to the indiscriminate use of coal, namely—

(i) Restricting use of different varieties of coal for definite purposes by a series of legislations to that end, and
(ii) Creating an educative influence and atmosphere in the industry and the trade with a view to encouraging and effecting the above, with the establishment of information bureaus as a necessary adjunct to the Government mining department.

The second process can be taken in hand now and, if properly conducted, will create a healthy atmosphere in the coal trade. The Railway Board is a big consumer of coal and it is a pity that this Government agency has been consuming the best types of coal available for their locomotives though other grades may quite suit their purpose. If the locomotives of our Railways are gradually fitted with the necessary modifications to burn powdered coal, the question of consuming low grade coal can be solved and the coal with high ash may thus be better utilized. Such experiments have been quite successful in the U.S.A. and other countries. The Coal Mining Committee (1937) has given examples where some amount of inferior grade coals was used by the Indian Railways. But the question is not whether the Railways have used inferior coal but whether the Railways can wholly utilize the coal, which is metallurgically useless. It is highly desirable that the Government of India jointly with the Railway Board should be persuaded to scrutinize this matter immediately with a view to using exclusively the inferior grade coals, preferably in pulverized condition in their locomotive boilers. The Railway Board should make a serious move in fitting up locomotives with adaptations for pulverized coal firing, and while importing, should attach this specification of pulverized coal firing.

In order to effect proper and efficient utilization, the various physical and chemical properties of coal should also be definitely known. It is a good sign that the Government of India has recently established the Board of Scientific and Industrial Research and that recently the Geological Survey of India has directed more attention to the development of coal and other economic mineral resources of the country. This step might be purely a war-needed measure but these improved conditions for mineral investigation require to be placed on a permanent basis by establishing separate fuel research and mineral research laboratories.

The standardization of methods of purification, blending, washing and preparation for the market may be undertaken by the Board. The different specifications for various uses may also be evolved and standardized by this Board. In order to carry out this function properly there should be under this central Board of Scientific and Industrial Research two separate research stations to be directly under respective expert bodies, namely—(i) Fuel Research Board, and (ii) Mineral Research Board. The Mineral Research Station should be allowed to develop in the Geological Survey of India and the important properties of the ore and gangue minerals and the nature of the associated rocks should be studied in each and individual case.

It would be a great achievement if an independent and well-equipped Fuel Research Station is started without delay in the coalfields for tackling various problems of fuel research. But so long such an independent Fuel Research Station is not actually brought into existence due to the unsettled conditions arising out of the present great war, fuel research may, however, be immediately started in a systematic way at the Alipore Test House or in the laboratory of the Board of Scientific and Industrial Research where necessary equipment and staff may be available and further expansion may be made at a moderate cost. Some amount of work may also be entrusted with the various recognized laboratories of the Indian universities and the private companies where necessary facilities and equipments are existing and in this way duplication of laboratory

equipments may be avoided. There would thus be a closer co-operation between the Government, industrial firms and university geologists and chemists.

A few points may be indicated about the utilization of various grades of coal. Different types of caking coal should be restricted for their proper use in metallurgical operations. The by-products from volatiles should be recovered as far as practicable. High volatile superior Raniganj coals should be used chiefly for recovery of volatiles for manufacturing various chemical products. Inferior grade caking coals should be subjected to carbonization in simple chamber ovens to produce better and uniform domestic coke and some of the more important by-products should be recovered from the volatiles. The possibility of starting low temperature carbonization plant on a big scale should be very carefully considered. Methods of soft or domestic coke manufacture now in vogue needs to be materially improved so that better quality and uniform smokeless fuel may be produced economically with the recovery of some of the by-products. The funds at the disposal of the Coal Grading Board and the Soft Coke Cess Committee may be utilized for such investigations, by granting subsidies or bonuses to offset the high cost of production in a scientific way. The question of recovery of oil and other by-products and their possible market in India should also be examined. High grade non-caking coals with low volatiles may quite suit the purposes of steam-raising plants which burn lump coals. Non-caking high-volatile and high-ash coals may be used quite efficiently in pulverized condition. High-ash coals with moderate volatiles may also be used in pulverized state. The quality of ash should in such cases be carefully studied. Inferior grade coals may be subjected to gasification; cheap producer gas or water gas may thus be generated at a central big plant and gas may be distributed to the surrounding places where small industries may spring up and use this gas as their motive power. Gas may also be used for domestic lighting, cooking, heating, etc. The gas industry may be considered to be a central power organization around which many other industries may gradually develop. From the water gas, for example, synthetic petrol or synthol may be produced and such plant may gradually develop to supply the needs of this country to a considerable extent. Recovery of more benzol from the volatiles in coal carbonization plants may be easily effected if Government protection is assured against the excise duty and unfair foreign competition, etc. There is also some possibility of getting cheap electrical energy from the coal and this question has already been the subject of some discussion in recent years (I would refer to the symposium on coal held by the National Institute of Sciences of India in August, 1940).

Coming to the industrial aspect of the subject under discussion, it is known that the iron ore reserve of India is very great and that caking coal reserve suitable for metallurgical operation is limited. This has led many people to make a strong case for conservation and restriction of caking coal by legislation and some have favoured schemes of nationalization of mines to achieve the desired end. Restricted use of caking coal for the future of iron industry should be accompanied by introducing better uses for the inferior grade coals. Recent researches tend to show (H.M. Fuel Research Paper, 1931) that non-caking coals can be converted to caking variety by some process of partial hydrogenation. This question has not drawn much attention of the Indian scientists.

I would conclude with an analysis of our present position of coal reserves. By the present wasteful process of mining a maximum of about 50% of coal can be recovered for our use. But by the improved stowing process about 75% or 80% of coal may be extracted; the life of the coal reserve would thus be much greater. The proper utilization of coal in near future and the process of blending, etc. are likely to increase the life of caking coal reserve.

According to current statistics, India produces annually about 25 million tons of coal (both caking and non-caking) out of which about 15 million tons of caking and 10 million tons of non-caking coals are raised. Out of this 15 million tons of caking coal about 3 million tons only go to manufacture metallurgical coke and 12 million tons are used for purposes other than hard coke manufacture. In other words, total production of coal for steam-raising, etc. is 22 million tons a year.

Now depending on the reserve figures as given by Sir Cyril S. Fox it may be mentioned that out of 20,000 million tons of workable reserve there are 5,000 million tons of high grade coals (both caking and non-caking variety) and the rest is of inferior quality. The details are given below:—

(i) Total caking coal reserve of good quality up to a depth of 2,000 ft. is ..	2,000 million tons.
(ii) Total non-caking coal reserve of good quality up to a depth of 2,000 ft. is ..	3,000 million tons.
(iii) Total inferior grade coals	15,000 million tons.

If we take the total extraction at 75% with improved method of mining with widespread sand stowing, then the available coal for the above three heads is given below in column No. I. The column No. II shows the available coal extracted at the rate of 50% by the present wasteful process of mining.

Column I.	Column II.
(i) 1,500 million tons of caking coal of good quality.	(i) 1,000 million tons.
(ii) 2,250 ,, ,, of non-caking coal of good quality.	(ii) 1,500 ,, ,,
(iii) 11,250 ,, ,, of inferior grade coals.	(iii) 7,500 ,, ,,

Now if we take the average present-day figures of production and current uses of coal, the life of the coal reserve will be as follows:—

(i) At the rate of production of average 15 million tons of caking coal, life will be *100* years for *caking coals* if universal sand stowing process operates.	(i) The life of *caking coal* will be only *66* years if the present-day mining methods continue.
(ii) At the rate of production of 10 million tons of non-caking coal, life will be *225* years for *non-caking* coal if sand stowing process operates.	(ii) The life of *non-caking coal* will be *150* years if the present-day mining methods continue.
(iii) Inferior grade coals are in sufficient quantity and will last for several hundred years.	

Taking, however, the restricted use of *caking coal,* i.e. with an average annual consumption of 3 million tons of caking coal exclusively for hard coke manufacture, the life will be *500* years in case of extraction by widespread sand stowing, but the life will be slightly more than *300* years if the present wasteful mining methods continue.

V. UNDERGROUND WATER RESOURCES AND SOIL CONSERVATION IN INDIA.

(Sections of Geology and Geography, Engineering and Metallurgy, Agricultural Sciences and Botany.)

DR. J. A. DUNN, Calcutta, presided.

1. DR. J. A. DUNN, Calcutta.

The study of underground water supplies is more particularly a geological problem and, to be effective, must be the work of specialists. To date, the work of the Geological Survey of India has been general in character, the cadre has been too small to permit of any well-defined specialization amongst its staff, and underground water investigations are normally wedged in between other enquiries. The importance of underground water supplies to India is so great, however, that the time has undoubtedly come to form a special section of the Geological Survey—a Water Conservation and Engineering Geology Branch—which will devote the whole of its time to such enquiries as this.

The problem of underground water should not be a provincial matter. Water seeking into the alluvium in the Punjab ultimately finds its way under the United Provinces, Bihar and Bengal. Overpumping in one area may lead to shortage in another. Vast numbers of tube wells are being put down, and an immense amount of detailed compilation concerning the various horizons passed through awaits to be done. Even at this early stage in the use of underground waters in India the control of all tube wells should be placed advisedly under one central authority—the Geological Survey of India.

Turning now to the question of soil erosion it should be remembered that the ultimate cause of all erosion is crustal uplift. Nature's demands are inexorable, but can be slowed down. Erosion is most vigorous along the edges of plateau, for example, along the northern edge of the Hazaribagh plateau in Bihar where bad lands have been found all along the head-waters of the streams flowing from the plateau. Gully, or vertical erosion, can be slowed down by a system of rivers to flatten the stream gradients, lateral erosion can be slowed down by encouraging jungle growth. Whatever is done in India to combat erosion it must be accompanied by a thorough appreciation of the forces of nature responsible, and in my view any investigations should be made through the medium of some such central organization as the Geological Survey of India.

2. DR. K. BISWAS, Sibpur (Howrah).

The problem of soil conservation is intimately connected with the various plant communities forming the vegetation which covers the soil surface. Diverse types of soil erosion caused directly or indirectly by the operations of biotic cum meteorological factors in different parts of the world have reached such a stage that the study of the question has proved to be of international importance. Ruthless denudation of forests in many parts of this country upsets the balance of succession of vegetation and exposes the earth's crust to the mercy of the sun, rain and wind—the prime causes of soil erosion.

The microflora including bacteria, fungi, algae and liverworts forming the earliest cover vegetation of the soil play by no means less important rôle than that of the herbs, shrubs and trees composing the different associations in a forest. The study of the microflora and the vegetation of the forest floor, particularly the associas, consocias and ecads, is gradually gaining in importance. Disturbance of the natural succession of plants forming the different storeys of vegetation in a forest land as observed by me in different parts of India, especially in North and East Bengal, Bihar, Orissa and the Eastern borders of Bengal and Assam and

South Burma, led to results which seriously affect the health and wealth of people and the routes of communication. A glance at the different parts of the vast plains affected by soil erosion, particularly the hilly regions of the Eastern and the Western Himalayas and the Deccan Peninsula, will clearly reveal the havoc caused by soil-erosion. There have been frequent floods and damages by cyclone; rivers and streams have been choked up and the soil is deprived of its fertility.

Cultivation of tea, cinchona, coffee and other economic plants by following antiquated and rather unscientific methods leads in some instances to rapid erosion of the hill sides and thereby brings about frequent land-slides in those areas much to the loss of the State and more permanent damaging effect to the people of the plains. Random cultivation and grazing of cattle in such areas should also be controlled. The loss of revenue caused by soil erosion which ultimately affect health, wealth and communication of people, when properly measured, would be enormous. Modern methods of cultivation by which soil may be conserved and at the same time larger and quicker yields of the economic plants may be ensured in a smaller controlled area, should therefore be adopted.

The study of vegetation in relation to soil erosion and soil conservation is really a special subject of study. Such a study needs prolonged investigation in the field and the herbarium. Auto-ecology and Syn-ecology of the floristics of forest areas are essential to tackle the problem of soil conservation. Such a study of the local floras will also throw a flood of light with regard to growing selective species of plants of economic and industrial value in a forest land which will not only prevent soil erosion but also yield considerable revenue to the country.

It is, therefore, imperative that a board consisting of able and experienced geologists, botanists, engineers, soil chemists and meteorologists should be formed without further delay. Such a body of scientists is expected by team work, to deal with the question of soil conservation in an effective manner, as has been the experience in overseas countries.

3. PROF. J. N. MUKHERJEE, Calcutta.

Soil and water conservation are interlinked in several ways. The study of these subjects has received increasing recognition in recent years. There is available quite a large number of interesting publications, including text-books, which deal with various aspects of soil conservation including erosion and the part played by what the Americans have graphically expressed as the run-off, fly-off and percolation of moisture deposited from the atmosphere. Various methods have been tried to control erosion under different conditions and a large body of useful information is given in these and current periodicals. The study of these subjects is also related to the much broader subjects of land utilization and its scientific, social and economic aspects. It is a pity that the study of soil science including soil engineering which deals with the scientific aspects of soil and moisture conservation in the soil has yet made little headway in India. The subject is, however, receiving increasing attention in our agricultural colleges and institutes. In the M.Sc. course for Geography in the University of Calcutta soil science and land utilization are included as parts of the curricula of studies. Actual study of the extent of soil erosion and measures to control them have been restricted in India mostly to hilly regions of steep slopes, and the Forest Departments, especially of the Punjab, have done some valuable work. But only a fringe of the problem has been touched. There has been no survey of the extent and degree of damage done by different types of erosion caused by rain water, rivers, wind or waves. The Crops and Soils Wing of the Board of Agriculture and Animal Husbandry in India at its meeting held at Delhi in December, 1939, discussed some aspects of the erosion problem and adopted certain recommendations made by a sub-committee appointed by it to consider the steps to be taken for the survey of erosion and measures

to control it. The first necessity is the survey to which reference has been made. Apart from the information gathered by the forest departments, the All-India Soil Survey which has been initiated by the Imperial Council of Agricultural Research is expected to obtain some valuable information. The Geological Survey have also probably got some useful information. However, the best course to adopt will be to assign the task of carrying out a quick survey of the broader features of the extent and nature of erosion in the country to a group of workers definitely appointed for this purpose and working in close association with the men engaged in the Soil Survey and with the Soil Science Committee of the Imperial Council of Agricultural Research and the Geological Survey and the Forest, the Irrigation and the Communication Departments. These various bodies have contact with different aspects of soil conservation and a Central Soil Survey Committee should be established for purposes of co-ordination. In fact, Sir John Russell in his report on the work of the Imperial Council of Agricultural Research suggested the establishment of such a committee, and the Soil Science Committee at their meeting in Simla in 1941 suggested the formation of such a Central Soil Survey Committee consisting of representatives of the Soil Science Committee, the Geological Survey, the Forest Research Institute, Central Board of Irrigation and the Communications Department. After a preliminary reconnaissance survey and the collection of available information have been made, the Committee could indicate the areas which required immediate attention as also more detailed surveys.

For anti-erosion work and control of erosion, the following scheme has been suggested by the Crops and Soils Wing of the Board of Agriculture and Animal Husbandry:

..........'for limited areas with local problems there should be anti-erosion Boards which would

(1) define the problems,
(2) devise measures for their solution, with due regard to any readjustment that may be necessitated thereby,
(3) undertake propaganda among the land-owners and cultivators likely to be affected,
(4) be responsible for the immediate oversight of the carrying out of the measures proposed.

For each Province or State it is suggested that there should be a Provincial or State Anti-Erosion Committee (especially where a whole Province or State is affected by erosion) which should contain members of all the Departments concerned, plus representatives from the Anti-Erosion Boards where these exist. There should also be non-official representatives of science and of the public. Such a Committee should devote itself particularly to Provincial or State aspects of (1) policy, (2) co-ordination, (3) expenditure, (4) research.

..........there should be an All-India Anti-Erosion Committee. It should deal with (1) pooling of information, (2) encouragement of research, (3) publication, and (4) the larger questions of (*a*) methods, (*b*) survey, (*c*) policy. This Committee should work in close liaison with and hold joint sessions with the Standing Soil Science Committee of the Imperial Council of Agricultural Research.......... As the Central Board of Irrigation has been devoting much attention to anti-erosion problems, its collaboration should be invited.

..........India should take full advantage of the experience now accumulated in the United States of America regarding both the technical and administrative aspects of anti-erosion work.'

Coming to the question of underground water resources, I think there will be no difference of opinion that this is a matter which comes within the activities of the Geological Survey. Here also a complete survey is urgently required for several purposes. On account of the characteristic succession of seasons in India we have most streams and shallow tanks

drying up during the dry season over large tracts in most parts of the country and the importance of the question of supply of water at the time of the year when it is most required is obvious. Potable water which has to be drawn from sub-soil resources is inadequate in quantity and unreliable in quality over large tracts with consequent inconvenience and high incidence of avoidable diseases and death rates. Water for the irrigation of arable land is insufficient in large tracts during the rabi season even in regions blest with irrigation canals. The tube well has brought great relief in many places in regard to potable water and is likely also to play a great part, as pointed out by Sir William Stampe with reference to conditions obtaining in the United Provinces, in irrigation of arable land. A fairly accurate survey of the available amount of underground water is, however, required and immediate attention should be given on a planned basis to the supply of water for potable purposes and having a reliable quality. The phenomenal number of surface wells supplying water of very doubtful quality all over the country testifies to the urgency of strenuous measures in this regard. Closely connected with the supply of water from underground resources are several aspects of moisture conservation, control and guidance of flow in rivers, floods, and surface and subsoil drainage. In my opinion here also a co-ordinating central body would be helpful but in this case the Geological Survey should be enabled by Government to complete, expeditiously at least, a broad survey of underground water resources. The survey of springs valuable from either the industrial point of view or for public health should be specifically admitted in the work of the survey.

4. Mr. N. N. Chatterjee, Calcutta.

It is well known from experience that the underground water resources depend mainly on the geological structure of the country, the nature of the rock groups present therein and on the sources of water supply. The different strata may get the supply of water either from the annual rainfall or from the perennial rivers and underground drainage. As an example, the conditions of underground water supply in the Deccan Trap area are entirely different from those found in the Indo-Gangetic alluvium. And even in the Deccan Trap area the geological structure and conditions governing water supply may be different at different localities giving rise to irregularities in the matter of water supply. It is, therefore, highly desirable that a detailed geological knowledge about the underground structure, nature of the rocks present should be procured before any decision is made as to the site of a well and to the depth to which the wells should be sunk. It is thus evident that a specialized knowledge of geology of these distinct regions is absolutely essential in order to have expert opinion on the matter.

Before we discuss the subject, it is, therefore, necessary to divide India into the following five regions according to the geological framework:

(i) Deccan Trap Country,
(ii) Granite Country,
(iii) Schistose and Metamorphic Country,
(iv) Country of sedimentary rocks like sandstone, shale, limestone, etc.,
and (v) Indo-Gangetic Alluvium Country; other big river valleys and deltaic regions.

From the geological knowledge at our disposal today, it may be said that very favourable and sometimes artesian conditions are found to exist in the Indo-Gangetic alluvium country. From the bore-hole records available it is known that there is a number of suitable pervious beds at different depths overlain and underlain by impervious layers making the conditions suitable for accumulation and storage of water. There are indications to show that some of these impervious beds are however not continuous for a very good distance. The different strata get ample

supply of water from so many perennial rivers and streams running through the regions of Northern India that in case of large town planning in this belt I think there should be no difficulty in getting sufficient supply of water from tube wells.

A reference may be made to the recent publication by Dr. Coulson on Geology and Underground Water Supply of Calcutta (*Mem. G.S.I.*, Vol. 76, 1940). The report contains some useful bore-hole records and other information regarding underground structure of Calcutta. It must be said in this connection that in the absence of any deep boring record we do not possess even today a complete knowledge regarding the entire thickness of the Indo-Gangetic alluvium and the nature of the different beds occurring in it. The few borings that were made at different places like Ambala (701 ft.), Lucknow (1,336 ft.), Agra (481 ft.), Fort William (481 ft.) and Garden Reach (1,306 ft.) could not however reach the rock bottom. We are thus even now in the dark as to the nature of the rocks underlying the Indo-Gangetic alluvium. It is suggested that a trial boring may be sent down to a great depth, say 5,000 ft. so that rock bottom may be reached. This might also give indications about other water bearing strata at greater depth and would also supply valuable scientific data regarding the rocky strata underlying the alluvium. Supply of good drinking water has already been obtained at different moderate depths like 250 ft., 350 ft., 500 ft., etc. and throughout Bengal many tube wells at shallow depths like 100 ft., 150 ft., 200 ft., etc. have also been quite successful.

Although potable water has been obtained in some parts of Calcutta and Howrah at depths less than 200 ft. it is necessary to send a tube well to at least 350 ft. or 400 ft. and sometimes even up to 750 ft. to get sufficient supply of good drinking water. The evidence of strata logs of the different tube wells indicates that there are sometimes no continuous impervious beds which would shut off different layers of water but it should also be pointed out that there is a definite variation in quality of water within very short distances which shows that there are definite layers of water of different qualities which are prevented from mixing with one another apparently due to some local conditions. At present Calcutta uses 70 million gallons of filtered water a day. To supply this water a battery of tube wells would be required. The amount of water extracted at present by tube wells at Calcutta and Howrah and their vicinity is relatively very small and there has been sufficient natural replenishment. But if the number of tube wells is increased over a localized area there may be the danger of the quality of water deteriorating owing to insufficient replenishment and due to infiltration of unwholesome water from other levels. There may be another danger of local subsidence due to over pumping of huge amount of water per hour but this may not happen if the tube wells are sent down to a depth of 1,000 ft. or more. These are some of the local problems regarding Calcutta's water supply and these should engage the attention of the engineers and water supply experts. Similarly the local conditions should be carefully studied for solving the water supply problems in different parts of Indo-Gangetic alluvium region.

In all other parts of India the above conditions of water supply are entirely absent. We know that the granitic and other igneous rocks develop series of regular joints besides some irregular cracks and fractures. The different igneous rocks decompose and alter on weathering differently and even different varieties of the same rock type may behave differently towards weathering. The underground structure of the locality should be very carefully examined and the geological section showing the arrangement of different varieties of rocks should be accurately prepared. The nature of the compactness of the rocks or portions of rocks, pervious and impervious nature of the rocks, the nature of joints, cracks, fissures and fault planes, if any in the different rocks, should be studied and carefully recorded. The nature of the topography of the country, the annual rainfall, distribution and location of streams and rivers should also

be noted. These data when accurately collected will guide a geologist to indicate where the well should be sunk.

The metamorphic rocks develop schistosity and foliation which help in the matter of percolation of water and the different varieties behave differently in this respect. Fault if any should also be noted. These planes of weakness, the nature of topography and the distribution of rivers, pervious and impervious nature of the rocks, etc. should be studied in the particular localities where underground water has to be tapped.

In a country consisting of sedimentary rocks like sandstone, shale, limestone, etc. the geological structure should in the first instance be noted, that is to say, whether the rocks are horizontal, slightly inclined or severely folded, etc. The arrangement of the pervious and impervious beds and the presence or absence of joints, fissures and fault planes, annual rainfall and the distribution of streams are important factors governing the underground water supply. The limestone country has got some of its own characteristics and topography and there may sometimes be a regular drainage of underground water though the surface indicates no water. The limestone country has, therefore, to be examined on its own peculiar conditions before a definite opinion is advanced regarding underground water supply.

Of all the different regions the Deccan Trap Country, however, covers a very wide area as much as two hundred thousand square miles in India. Any one who has travelled far and wide over this Deccan Trap Country will admit that the people in most parts of this region face the great problem of water supply and this problem has been engaging the attention of the local governments, States and local municipalities and as a result of repeated enquiries many workers examined from time to time several localities in such a country and the results of some of these investigations have been recorded in the *Quarterly Journal* of the Geological, Mining and Metallurgical Society of India. Several suggestions have been made in those papers regarding the choice of sites for successful wells in the Deccan Trap areas, and many of those recommendations have been found to hold good in Bansda and Khilchipur State and at several other places. If detailed work in this direction be carried out at various places, a good amount of reliable data would be at our disposal and more definite proposals and recommendations may be advanced regarding suitable sites for wells and the depth to which such wells should be sunk.

It must be admitted here that in many cases fruitless attempts were made without having any proper scientific guidance and a good amount of money was thus wasted. It is, therefore, suggested that the Provincial Governments of Bombay, the Central Provinces, and the different States should immediately start separate water supply departments or a joint department with geological experts to collect all possible data from different localities and the recommendations of such experts if carefully followed would in almost all cases be crowned with success. The reports on water supply investigations when published will go a long way in helping others in this line. A reference may be made to the water supply department of the United States Geological Survey and to their long list of publications on this subject. It is, therefore, suggested that the India Government should be moved to give this subject a due consideration so that they might develop a 'Water Supply Section' in the Geological Survey of India and expand the department accordingly with necessary well-qualified hands. In course of near future this department will thus be able to gather necessary materials and useful data regarding the different regions of India and will continue to do useful service to this country and its people in solving the intricate problem of water supply.

5. Mr. Suprakash Ghosh, Calcutta.

In this very interesting discussion, we have viewed the problem of soil conservation or rather soil erosion from the standpoint of Geology,

Botany and Soil Science. If the study of the subject is to be complete, we must take into consideration the geographical aspect. The geologist, the botanist and the pedologist are all variously interested in the problem. The geographer is interested also. He also views the subject in his own light.

The geographer is vitally interested in the elements of the landscape whether it is natural or whether it is cultural. He is concerned with the various physical and biological phenomena going on the surface of the earth and their reciprocal bearings. The soil is a very important factor in the natural landscape and soil erosion is a distinct surface phenomenon of the earth and in that case the soil erosion problem is of direct interest to the geographer. However, the real interest of the geographer is to analyze how soil erosion affects the various forms of human activities of the area and how human activities in their turn affect soil erosion. The correlation of these two belongs to the province of Geography.

If the proposed All-India Soil Survey undertakes a survey of soil erosion areas, it is feared that it will not utilize the services of the geographer, owing essentially to the spirit of neglect that is marked towards the encouragement of teaching and research on Geography. However, as a keen student of Geography, I may add that the survey reports can never be complete without the contributions of the geographer. It is high time that the authorities of the Survey realized the real position of the soil geographer. The United States Soil Survey, the best organized in the world, has owed its success largely to such great soil geographers as Dr. C. F. Marbut, the leader of the modern school of American Pedology, Prof. Louis Wolfanger of the Universities of Michigan and Columbia, Dr. Hugh Bennett and Dr. Oliver Baker of the United States Department of Agriculture.

The next point on which I wish to touch is that we must not confuse soil conservation with the soil erosion problem. In general soil conservation has two distinct aspects—the soil erosion problem, that is to say, the problem of checking the bodily removal of the soil cover; and secondly the problem of conserving the inherent productivity of the soil, which we call soil fertility. The checking of soil erosion is largely the work of the pedologist, while the maintenance of the fertility is the work of the agricultural expert. I do not wish to discuss the various schemes of soil erosion control, like the famous 'Seventeen-point program' in the U.S.A. The agricultural expert can do the needful by regulating the system of cropping. In India, there has been a gradual falling off in the productivity of the soil, even in such regions as Bengal. We must put a stop to the present system of 'mono-culture' or one-cropping system. It is time that we consider seriously the introduction of suitable systems of crop-rotation and inter-culture in Indian agriculture, even in Bengal where in certain restricted localities the soil fertility is being renewed annually.

From all what I have said, one thing is apparent that a geographer has as much say in the matter of soil conservation as a geologist, a botanist and a pedologist.

Resolution adopted at the close of the Discussion.

This meeting resolves that (*a*) for the purposes of industrial and agricultural utilization of water and sanitary and other uses of drainage and human consumption of water, a systematic survey of the water resources including underground sources of India should be undertaken by Government through the Geological Survey of India and such other bodies whose co-operation will be helpful; (*b*) for purposes of land utilization and soil conservation, an erosion survey should be carried out by the Imperial Council of Agricultural Research along with the scheme of All-India Soil Survey with such co-operation as the Geological Survey and Provincial Forestry and Agricultural and Botanical Departments may offer.

VI. NITROGEN FIXATION BY BLUE-GREEN ALGAE.

(*Section of Botany.*)

DR. K. BISWAS, Sibpur (Howrah), presided.

1. DR. J. BOYES, Krishnagar (on military duty).

Symbiotic nitrogen fixation in the Leguminosae is a complex interrelationship between host plant and micro-organism. The physiological environment of this fixation is under investigation; the micro-organism does not fix nitrogen in vitro but only in the presence of the legume host.

Excretion of nitrogen (alanine and asparagine) takes place from the micro-organisms. Virtanen claims that a considerable portion of this reaches the surrounding growing medium.

Mixed cropping of legumes and non-legumes would thus largely benefit the latter without requiring artificial nitrogenous manure.

2. DR. J. C. SEN GUPTA, Calcutta.

Except some work on the fixation of nitrogen by Azotobacter in some soils near Calcutta, I have done no work on the fixation of nitrogen by blue-green algae. I have, however, followed the development of the question in Bengal. The question originated from an observation by Howard (1924) that rice can be grown on the same land for long periods without the addition of manures to the soil. This may either be the result of fixation of nitrogen in soil or the plant may harbour a nitrogen-fixing symbiont after the manner of Leguminoseae. Viswanath (1932) has obtained indications that rice plants possess the power of assimilating nitrogen, and Sen (1929) demonstrated the occurrence of nitrogen-fixing bacterium in the root of the rice plants. As there is abundant growth of algae in the water-logged period of the soil, the question arose about the possibility of the algae present being involved. De was sent by the I.C.A.R. to England to work out the problem under Dr. Fritsch.

There are some records of nitrogen-fixation by blue-green algae chiefly by *Nostoc* and *Anabaena*. Copeland (1932), however, recorded positive results with *Oscillatoria princeps*, *O. formosa*, *Spirulina labyrinthiformis* and *Phormidium laminosum*.

De after prolonged work succeeded in obtaining uni-algal bacteria-free cultures of some species of *Anabaena* and *Phormidium* on silica gel and satisfied himself that the cultures were bacteria-free by getting them tested by a bacteriologist at Rothamstead.

De found that of the species tried in this way three species of *Anabaena* gave clear evidence of nitrogen fixation whereas *Phormidium* gave no positive result. He also investigated the question of enhancement of the growth of azotobacter in the presence of blue-green algae and due to the effect of the decomposing algae. He found that the presence of algae retarded the growth of azotobacter and that the fixation of nitrogen was due to the blue-green algae only.

I think another aspect should also be investigated, namely the effect of organic substances leaching out of the growing algae in the neighbourhood, on the growth of azotobacter.

R. N. Singh seems to have since confirmed De's findings, though Chaudhury has reported in '*Nature*' that the fixation of nitrogen is not done by the blue-green algae themselves.

3. DR. S. R. SEN GUPTA, Calcutta.

Apart from the common non-symbiotic nitrogen fixing organisms the phenomena of nitrogen-fixation has been attributed from time to time to various groups of micro-organisms including *Fungi*, *Actinomycetes*, *Algae* and even *Protozoa*. However, it has been established beyond doubt that *Fungi*, *Actinomycetes* or *Protozoa* cannot fix any nitrogen. Earlier

theories regarding nitrogen fixation by algae have been ruled out by careful chemical analysis by Page and Bristol Roch. Allison again revived the topic in 1930 but his method is open to objection since 'Cultures are to be exposed to the ultra-violet rays to kill the contaminating bacteria enclosed within the algal sheath, but exposure should be for a short period so as not to injure the algae'. It is well known that bacteria are more resistant. Further it is not possible to kill bacteria without injuring the algae within which they are enclosed. It may be quite possible that blue-green algae isolated by Dr. P. K. De are able to fix nitrogen, but the results need confirmation by a number of workers working independently. Unfortunately Dr. De has no stock culture nor does he propose to renew this line of work in near future. The fixation of nitrogen by azotobacter or nitrite formation and nitrification by nitrosomonas and nitrobacter are intimately connected with the life process of these organisms. For instance, the oxidation of ammonia and nitrite by nitrifying organisms supplies them with energy to carry on all the vital activities. No such vital relation has been established in the fixation of nitrogen by algae as they can do without any fixation. Moreover, far from any injury they grow luxuriantly in pressure of salts of nitrogen. Like Photo-nitrification of Dr. Dhar or nitrite formation by Heterotropic Bacteria—results of many of the micro-biological investigations are often illusive and need confirmation.

4. Dr. K. Biswas, Sibpur.

The Chairman wound up the discussion with the remark that he had personal acquaintance with the work carried by Dr. De under Prof. F. E. Fritsch in the Queen Mary's College, London. At first there was considerable difficulty in obtaining bacteria-free cultures of *Anabaena*, *Phormidium* and other blue-green algae. Dr. De, however, succeeded ultimately in obtaining bacteria-free cultures of several species of blue-green algae and proved conclusively that some species of *Anabaena* could definitely fix atmospheric nitrogen. Dr. De might not have been able to continue his work in India in the absence of the same facilities as available in London. Dr. De's experimental results are substantial contributions towards this important problem. Dr. Biswas held that the vast quantities of algae which grow year after year, and are finally deposited on water-logged paddy fields and swamps, are likely to play an important rôle in increasing the fertility of the soil of the rice fields resulting, as they do, in a more or less uniform quantity of yearly yield of the crop. Dr. Biswas fully supported Dr. J. C. Sengupta's views, and he hoped that further investigations would throw more light on this problem of national importance.

VII. FOOD AND FODDER PRODUCTION DURING WAR TIME.

(Sections of Medical and Veterinary Sciences, Agricultural Sciences, Physiology, Botany and Chemistry.)

Dr. F. C. Minett, Muktesar-Kumaon, presided.

Short abstracts of papers contributed by the various officers under the Central and Provincial Governments appear below:

1. Dr. W. Burns, Delhi.

A variety of measures to stimulate food production have been applied in provinces and States. The success of these during the past *kharif* season should now be apparent. The key to increase of food is organization of production and marketing. The large land-owner has a special responsibility. Where such local leadership does not exist, some individual

or committee must undertake the work. A guaranteed market at guaranteed prices with the certainty of these prices going to the primary producer is necessary. Cattle being essential for tillage and transport must be kept in good condition. Increase in green (particularly leguminous) fodder is imperative. Additional fodder can be produced on otherwise unused land along the edges of water channels. Fodder reserves of *kadbi* and dry grass should be a permanent part of our agricultural organization. Increase of silage production is possible only on large estates. A real long-term agricultural policy with machinery to implement it should grow out of war time experience. Improvement of the condition of the cultivator, by increasing his cash income, must always be a major objective. Due to increase of his purchasing power, such prosperity would react favourably on industry.

2. Mr. F. Ware, Delhi.

A larger number of calories for human consumption can be obtained from a given area if crops that can be eaten by human beings are grown rather than by the growing of feeding stuffs for animals. There are, however, two other important considerations to remember when crop planning, even in those countries where the bullock is not the usual means of transport. These are—

(i) animal manure is required to maintain the fertility of the soil;

(ii) animal products, such as milk and eggs, supply proteins of a higher biological value than plant products.

In India there is a third consideration, viz. that our bullock power must be maintained, and for this purpose the growing of crops which will supply at least a residue which will form a suitable diet for our bullocks is essential.

A good deal more could be done to improve our grazing lands and there is a movement to reclaim as much as possible of that land which is known as cultivable waste. If this is done, it would be a wise move to earmark all such land for the growing either of fodder crops or at least for such millets and pulses as *jowar*, *bajra*, *ragi*, soya bean, etc. which will supply both a good human food and a good residue for cattle.

In war time it is essential that there shall be as little waste as possible and one of the ways in which the efficiency of our animals and poultry can be maintained is by the prevention of contagious diseases. Those requiring most attention in this country are rinderpest, foot-and-mouth disease, tuberculosis, Johne's disease, contagious abortion, sterility and mastitis in cattle, the different forms of pleuropneumonia, sheep-pox and the nasal bot in sheep, and Ranikhet disease in poultry.

3. Dr. N. Das, Delhi.

There are three principal ways in which food and fodder production can be increased—(*a*) by making fresh additions to the acreage under food, (*b*) by more intensive cultivation, and (*c*) by substituting more quickly ripening varieties of food crops or by varying the crops on land. Now, some 153 million acres of land in this country are classed as 'cultivable waste other than fallow'. *Prima facie*, a substantial proportion of this could be brought under food crops, but the very fact that this has not been done during the pre-war years shows that there are many practical difficulties. The difficulties are those of irrigation, manures, fertility, tenancy, etc. Most of the lands now under food crops are marginal lands and any additional lands to be brought under the plough must prove less remunerative, unless courses (*b*) and (*c*) are adopted. To induce the cultivator to take up the cultivable waste other than fallow, a certain minimum price must be guaranteed and there must be some definite State policy of subsidies. This has been done in Eire and Great Britain (the Agricultural Development Act of 1939 and the famous wheat, barley and sheep schemes are notable examples) and there is no reason why

similar steps cannot be taken in India. The institution of Agricultural Executive Committees in every district and taluka would also be helpful.

Another aspect of the food and fodder production drive is the large scope we have for the raising of vegetables. Out of 257 million acres of land cropped in British India, only less than 6 million acres are under fruits and vegetables. The 'kitchen garden habit' would be a step in the right direction.

In any case, what is important is to recognize that mere slogans will not do. There must be central planning with adequate financial provision.

4. Rao Bahadur B. Viswanath, Delhi.

The problem of food production is essentially one of obtaining more yield per acre than previously without any deterioration in quality. If by intensive cultivation even all round increase in yield of 5 to 10% is registered it can shift the position from deficiency towards sufficiency.

But it is concerned not only with man but also with his domestic animals. So in all questions of food production planning, efforts should be towards growing such food as will benefit both man and animal. Rice, jowar and wheat produce besides grain straw suitable for feeding animals.

Further a balance has to be struck between the production of food of animal and vegetable origins. The production of the former requires four times more of land than the latter.

Increase of food supply may be attempted mainly in two ways, firstly by a change over to crops which give greater food value per acre, and secondly by manuring.

For example, tapioca and sweet potatoes can yield nearly four times as much of nutritive matter than rice or wheat on the same area. Edible mushroom is a cheap and satisfactory food.

As regards manures, lack of imported fertilizers can be made good with indigenous fertilizers like oil-cakes, rock phosphates, bones and sewage sludge.

5. Major G. L. Lillies, Delhi.

During the year 1940-41 Military Dairy Farms were first confronted with the problem of how to provide a sufficiency of fodder for the greatly increased herds which had to be maintained for the provision of large quantities of milk to the expanded army in India. In the case of Dairy Farms in Cantonment Areas, whose inadequate lands had already been encroached upon for building of new accommodation for troops, the difficulty could only be overcome by the purchase of increasingly large quantities of dry fodder, principally *bhoosa* in the North and hay in the South. This was supplemented to some extent by ploughing old pastures for fodder production where either irrigation supplies were sufficient or rainfall was normally adequate.

On young and dry stock farms situated in the canal colonies of the Punjab where an average increase in herd strengths of 400% was anticipated, the problem was slightly different and the difficulties could only be overcome by a change from commercial crops, such as cotton and *toria*, to fodder crops. These farms are cultivated by tenant farmers on the *batai* system and the obstacles to be overcome were therefore firstly to ensure that the change should not reduce the standard of living of our tenants and then to persuade members of that very conservative class that they would not suffer financially by the change. Both these obstacles have now been successfully surmounted.

6. Dr. W. R. Aykroyd, Coonoor.

In comparison with many other countries, India is a self-contained country as regards her food supply. Both imports and exports of food are small in relation to indigenous food production. Nevertheless rice imports during the last 10 years have ranged from 1·1 to 2·6 million tons

annually and in 1939-40 exceeded 2 million tons, or about 6·5% of total rice supplies. The loss of imports has not been made up by restriction of exports. Exports previous to the war were small, so that any loss of overseas markets could have little effect. Actually the quantity of grain required for export has been increased as a result of the war, since Ceylon, cut off like India from supplies of Burma rice, has to be provided with food. Internal requirements of food have also increased to some extent.

Even in normal times the food supply of India plus imports does not cover requirements in the sense that the population is abundantly or satisfactorily fed. Because of the existing bare minimum level of diet, there is little margin of safety to allow for further restriction. It is, therefore, essential that more food should be produced and this applies in times of peace as well as in the present emergency.

The millets are satisfactory substitutes for rice from the standpoint of nutrition. More calories can be obtained from a given quantity of paddy or whole wheat in the form of rice or flour retaining a proportion of the outer layers of the grain than in the form of highly milled rice or refined wheat flour. The cultivation of vegetables, with special emphasis on green leafy vegetables, could be greatly extended and an increase in their consumption would improve the health of the population. In Ceylon special attention is being given to yams as a substitute for rice. Tapioca, a very productive dry crop, is undesirable from the standpoint of nutrition because of its low protein content, but when rapid calorie returns are needed its increased cultivation might be justified.

An energetic and successful 'Grow More Food' campaign might be of lasting benefit to India. Bold schemes for the colonization of waste lands in certain areas are to be recommended. To the nutrition worker, the food situation in India is thoroughly unsatisfactory in normal times. If India is to depend on the food which she can herself produce, large increases in the production of various foods are necessary to raise existing standards to a satisfactory level. These may be roughly estimated as follows: cereals, thirty per cent increase; pulses, one hundred per cent; milk and milk products, three or four hundred per cent; meat, fish and eggs, several hundred per cent; vegetables, particularly green leafy vegetables, one hundred per cent or thereabouts. There is plenty of scope here for the application of scientific methods to agriculture, animal husbandry and fisheries.

7. Mr. C. Maya Das, Lucknow.

During 1942 it was estimated that there would be a deficit of some 2·3 million tons of rice and about ·35 million tons of wheat in India. The failure of the monsoon during 1941, added to the pressure of demand against available food supplies, quite apart from the requirements of the fighting forces. The difficulties of transport by rail also contributed to local deficits. In these circumstances, it was essential that the utmost effort be made to increase the production of food and fodder crops during the present war.

Some of the obvious methods of bringing about such a result are as follows:—

(*a*) Breaking up culturable waste land to increase the total area under cultivation.

(*b*) Double cropping, whereby two crops are taken from the same acreage in one year.

(*c*) Replacement of non-food crops by food crops.

(*d*) Increased production by more intensive methods of cultivation, and

(*e*) Growing of more vegetables and quick-maturing fruit trees.

Each of these methods presents numerous problems. In the United Provinces many of these problems have been solved and during 1942, the estimated increased production of food grains and other consumable

commodities was 20 million maunds (about 740,000 tons) in addition to normal production.

8. Mr. A. J. Macdonald, Izatnagar.

In view of the general inadequacy of the diet consumed by large masses of the population, every effort should be made to supplement the present diets with 'protective foods'.

The egg is a very valuable 'protective food'. On the basis of equal weights the egg is a more concentrated food than milk, for it is richer in protein, fat, iron and the vitamins A, B, D and riboflavin. It is, however, somewhat deficient in calcium. In view of their exceptionally high vitamin D and iron content, eggs should be widely used in the diet of young children as a safeguard against rickets and anaemia.

The fowl is an economical converter of vegetable foods either into meat or eggs. Under village conditions fowls live practically entirely on waste foods. Fowls could be kept much more extensively without interfering with the human food supply.

Egg production ranks next to milk production in the efficiency with which the proteins of the raw feed are converted into edible animal protein.

Eggs are less liable than milk to disease contamination and as they keep much longer and are more concentrated they can be transported more readily over long distances.

Poultry flesh is extremely palatable and is of special value for the sick or wounded.

Poultry excrement is a valuable fertilizer.

The poultry population can be increased much more rapidly than other classes of stock. Propaganda to increase the poultry population is therefore more likely to benefit the war effort than other methods of livestock improvement.

9. Mr. K. Mitra, Patna.

Unlike those of other countries the immediate problem in India is to make good the shortage of grain (energy) foods caused by stoppage of import. (*a*) Planned cultivation of mealy tubers in areas not under cultivation, and (*b*) better utilization of *Mahua* crop (*Bassia latifolia*) may be undertaken.

Per unit of weight, nutrients in grains can be made available by (*a*) retention of cooking water, (*b*) malting inferior millets, (*c*) discouraging milling.

Increasing production of milk and flesh foods is difficult. Where necessary, facilities for better methods of collecting and curing fish should be encouraged.

It may not be advisable to introduce cultivation of soya bean in spite of its virtues in preference to common pulses unless (*a*) yield of nutrient per acre in the former be subsequently higher than those of latter, and (*b*) easy adoption of heat processing or better methods of cooking soya beans be a common knowledge.

Introduction of kitchen garden in the backyard of every house may form another line of attack. Apart from their value as protective foods vegetables will help (*a*) in giving a sense of fullness when the amount of cereals in the diet be below pre-war level, and (*b*) replace fruits in the diet. Excessive paring or dressing of vegetables should be discouraged. Storage of dry fruits and vegetables has a limited application.

The following members participated in the Discussion :—

10. Mr. A. C. Ukil, Calcutta.

He opened the discussion from the point of view of human requirements. He drew the attention of members to the fact that 81% of the cultivated lands in India was employed in the production of food grains and 19% for the production of non-food or commercial crops, in

which is included 4% for fodder crops, and that 22% to 40% of total land in India represented cultivable waste other than fallow. It was well known that there was not enough land in India for the production of adequate food for the human population and that on the testimony of Dr. K. C. Sen, 50% of cattle in India were underfed.

During war time, he thought that one should aim at 30% more production than in peace time. In such a case, two courses were open—(i) to make more land available for the cultivation of food and fodder, and (ii) to increase the production capacity of the soil by manuring and irrigational facilities and to double the crop in suitable areas. But one should not lose sight of the fact that in planning the food production, one must produce sufficient quantities of the protective foods and sufficient quantities of the energy-yielding foods, according to the requirements of the different groups of civil population (infants, growing children and adolescents, expectant mothers) and military population (soldiers and persons engaged in war industries). In planning the protein supply, the dairy cow should have priority over the more costly items, like eggs and meat. Fish should be considered in a country so rich in rivers and so completely encircled by sea. If it was found difficult to produce the required quality and quantity of food, attempts should be made to discover substitute foods of like nutritive qualities.

As regards cash crops, their cultivation should be limited to the needs of internal consumption and such exports as are available at the present moment.

Larger production of food should be accompanied by arrangements for an equitable distribution of food, which included matters like storage, transport, marketing, price control and even rationing, according to the needs of the different groups of population.

Mr. Ukil severely criticized the present Government policy in the provinces and at the centre since the beginning of the war and pointed out that the administration could hardly achieve this without the aid of science and scientific workers, as scientific research was needed not only in the direction of manuring, irrigation and drainage but also in finding out suitable strains of seed and alternate sources of food for the population. He, therefore, requested the appointment of a body of experts, on a central and provincial basis, who would supply the administrators with the necessary technical information. The administration could then pool the knowledge and co-ordinate the central and provincial activities in the solution of the problems of food production and food supply.

In addition to this, effective steps should be taken to prevent adulteration of food-stuffs, which is believed to be widely prevalent in war time. It is also necessary to undertake suitable educative work, to ask the people not to hoard food, to avoid misuse and waste and to adopt improved methods of cooking for the conservation of essential nutritive ingredients.

11. Dr. K. C. Sen, Izatnagar.

He said that in times of war, organized agriculture can meet the demands of war requirement in two important ways: firstly, by maintaining an increased production of food which is required for both civilian and army consumption, and, secondly, by the production of materials which go directly for the manufacture of army equipment. As we are concerned mainly with the question of food production, we shall discuss the subject somewhat in detail.

We have recently heard a good deal about the 'Grow more food campaign', but there appears to be some confusion as to what actually should be grown and where it should be grown. Circumstances no doubt differ in different provinces, depending on the agricultural conditions and requirement of the people. Wheat, rice or millets and other subsidiary crops may have to be grown in great quantities in different areas. It may be that due to this fact Bengal is considering the growing of more

rice, potato, mustard and pulses, whereas Assam is concentrating on rice and potatoes. We have heard that the shortage of rice is about 2,000,000 tons and obviously an attempt is being made to grow as much of this extra amount as possible. It has been pointed out by some workers that, from a purely nutritional point of view, it is an unsound policy to advocate the increased production of starchy foods like rice or potato in provinces which are mainly carbohydrate-consuming areas, but presumably this tendency will be found to be true with most of the poorer areas throughout the world. It would be ideal if people could be made to consume a mixture of 80% rice and 20% protein-rich feeds, such as soya beans or pulses, in ordinary times, but during war time, it may not be easy to change the fundamental dietary habits of the people.

In dealing with greater food production, we have to consider the following two facts: (1) Owing to the high price of fuel, most of the cow-dung will be utilized for this purpose and very little will be returned to the soil. It is also unlikely at this time that we can get a large amount of other organic or inorganic manures and transport them throughout the cultivated area. As such, we should not expect any very great increase in the outturn per acre during the war. (2) The only practicable course is, firstly to reappropriate some land now under non-food crops, secondly to increase the area under cultivation, and, thirdly to increase the area under double cropping which will augment the total yield. In order to produce 2 million tons of rice, we need roughly 6 million acres of land. Last year, in Bengal alone, 2,000,000 acres of land were released by the restriction of jute cultivation. There are about 12½ million acres of land lying waste as current fallow and culturable waste and a good portion of this can be utilized. If double cropping can be extended, this will mean a saving of land. As such, if proper arrangements can be made, the immediate requirement of food can be met by increased production.

What is therefore needed is a proper crop-planning scheme and in this connection he pleaded for a policy of 'hands off' the fodder crops and pasture areas. In any of our increased food production drives, animal labour will play a most vital part and they must be adequately fed. As it is, we have not enough to feed our cattle population, with the result that we get a very poor return from them, either in the shape of work or in the form of milk. In fact, we must increase the fodder production rather than decrease it.

It may be argued that increasing the rice area will provide as a bye-product a large amount of straw for cattle. This is true in a very limited sense. If pasture areas are ploughed up, we shall lose the grasses which are highly nutritious and replace them by a poor quality roughage like paddy straw, which does not contain any digestible protein. This will have a serious effect on milch animals, as it is well known that milk production requires a certain amount of protein intake by the animals and already there is a shortage of protein supply for cattle.

Apart from an increased demand for cereal grains, there has been a sudden increase in the requirement of milk and milk products. The major part of this demand is for *ghee* required by the army and a small part due to the stoppage of import from foreign countries. This increased demand is about 2·2 crore maunds per year in terms of fluid milk and forms about 5% only of our total milk production. If sufficient fodder crops and concentrates are grown, it is quite feasible to obtain this increased milk yield during war time. In fact, according to information available, Great Britain produced 10% more milk last year than in the previous year.

If extra land is available, he presumed that it would be almost impossible to restrict the cultivation of grain crops after this year's bitter experience, but wherever possible, a significant portion should be reserved for fodder crop production which should be widely distributed so as to provide regional self-sufficiency. Every attempt should also be made to

produce a certain amount of dual purpose crop, such as mustard in Bengal, gingely in the South, etc. which supply oil to the human population and good quality cake to the cattle.

While it is possible to augment the fodder supply by utilizing factory bye-products, like potato and other green vegetable peelings and by using tree leaves, the direction in which our main efforts should be made is in the large-scale preservation of fodder as silage and in the processing of straws by chemical methods so as to yield a better feeding stuff for cattle.

For a province like Bengal, which is faced with a shortage of her staple cereal crop and usually imports *ghee* equivalent to 60 lac maunds of milk from other provinces, and condensed and dried milk equivalent to over 1 lac maund of fluid milk from abroad, only one course is open. We must have about 8 million acres equivalent of extra land, partly by reappropriation, partly by double cropping and partly by the extension of cultivated acreage. Half of this area will have to be put under paddy crop, 1¼ million acres under mustard and 1 million acre under *matti kalai* or gram, 1 million acre under fodder crops, 250,000 acres under potatoes and the rest under fodder. The fodder and cake produced will meet the requirement of about 15 lacs of milch animals so as to give an increased production of at least 10 lac maunds of milk and also meet the extra food requirement of about 10 lacs of working animals. The enhanced milk production will meet the ordinary demands of *ghee* for the adults and dry milk products for children in Bengal and as such will release at least 1 lac maunds of *ghee* from other provinces for supply to the army. If a similar scheme of increased fodder production is adopted in those provinces which have a better class of milch cattle and usually produce comparatively more milk, the problem of increased supply of *ghee* to the army should not offer serious difficulties.

12. Dr. R. B. Lal, Calcutta.

I wish greater emphasis is laid on supporting the 'grow more food campaign' by making readily available expert advice of a practicable kind to those requiring such advice and also providing all facilities so that their difficulties, some natural and others man-made, are removed. If this could be done, the short-term food-growing campaign will receive the necessary stimulus and result in cultivation of the extra food now required. The second point is whether the less nutritious grasses can be replaced by more nutritious ones, in both forest and open areas.

13. Dr. Kalipada Biswas, Sibpur.

The subject of the discussion presupposed a 'Grow more food campaign'. To grow more food either by increasing fertility of the soil or by utilizing more land is self-evident. Different speakers have suggested different kinds of crops for their special food value and others have expressed the view that improved methods arising out of scientific investigation will have to be adopted for producing more food. This does not help us in our meeting war needs.

The subject of our discussion is, however, the production of food for war purposes. This is the immediate and pressing need and the question is at present to devise means for production of food and to utilize every inch of space available for growing some kind of crops or vegetables within a short period for our consumption. Self-sufficiency of a district or even a locality with regard to some kind of food to prevent starvation is imperative in the event of an air raid, in which case there is every chance of the area involved being cut off from the supply centre. There should, therefore, be a short-term or immediate scheme and a long-term scheme for tackling the question on a more elaborate and wide scale after peace is restored. The experience gained in this campaign of growing more food for war time will prove to be of value in dealing with broader and more lasting problems.

The supply of fodder is an equally wide and far-reaching problem inter-connected with agriculture, deforestation leading to soil erosion and other allied questions. Selection of fodder grasses is also important, as prussic acid is generated at a certain stage in the growth of indigenous or foreign species, however much it may be liked by cattle.

To find out ways and means for tackling the problem properly, it goes without saying that a committee of experts will have to be formed.

14. Dr. S. P. Agharkar, Calcutta.

The views expressed by previous speakers during the course of this discussion show that very little new can be said on the subject. The remedies suggested for increasing the production of food and fodder, viz. increasing the area of land under food crops, increasing the yield per area by manuring and other measures, and introduction of new and better food crops are the same as have been suggested in all periods of emergency. This being the case, what is really wanted is not a knowledge of the means of increasing food production, but a well-thought-out plan to overcome the numerous practical difficulties and suggestions for putting it into effect. To me it appears that nothing really useful can be done in a short space of time except by the Government, who alone have the power and means of giving effect to their decisions. In this, however, they will only succeed if they obtain the hearty co-operation of the people.

15. Mr. G. Panja, Calcutta.

In the 'Grow more food campaign' there are three important problems, namely monsoon, manure and men (labourers).

The first one is most important in Bengal. If there are sufficient timely rains every year, the chief crop, namely paddy, does not fail and consequently people get sufficient chief food and also utilize it for buying other articles in their dietary necessary for themselves and for their cattle.

Supply of water to the paddy crops is the most essential necessity and without it the solution of the food problem appears to be an impossibility. If we go to the villages of Bengal and ask the cultivators about their difficulties, the first thing they will say is 'Give us water to grow our rice crops every year'. If we have to look to the sky for water, we will not get favourable response every year. In a short-term plan, we cannot think of irrigation scheme through canals. The only thing we can think of is the *re-excavation of tanks* that are already present outside the villages. These tanks, although fairly numerous are no longer tanks but only shallow pools filled with silt. Any water that collects in them during the rainy season is quite insufficient to meet the demand of rice crops. All of them get dried up soon and there is no water left for the cattle grazing about during the summer. These tanks were excavated by our forefathers, probably centuries ago, and since then no re-excavation has been done. If these are re-excavated, they are bound to be filled up during a good rainy season and if the monsoon fails, water from the tanks can be utilized for purposes of irrigation and cultivation. It is my personal experience in a village that a big tank situated at the outskirts of the village saves rice crops from perishing by supplying water during scarcity of rains. Moreover, fish grown in these tanks will be an additional food. The expense of re-excavating these tanks will, I believe, be less than reclamation of waste lands and there is also no use in reclaiming waste lands if there is insufficient water available for cultivation. When there is a good rice crop every year, people will be able to buy more cattle for ploughing their fields and more milch cows for supply of milk and consequently more dung manure will be available. At the same time, poor labouring classes in the villages are not likely to go out of their villages to seek employment elsewhere and so the dearth of tillers of the soil will be greatly removed. It is only during famine years that labourers leave

their villages for service abroad and *Bhadralok* classes are greatly handicapped for shortage of labour.

In villages near rivers, the problem can be solved by installing pumps in the river wherefrom water can be pumped through small channels into the cultivable fields. The only objection to this is that the aid of such pumps may not be utilized every year.

In conclusion, I like to point out that the failure of monsoon is at the root of all food troubles in Bengal and if this is solved by re-excavation of at least some of the old tanks, it will give assurance of growing rice crops every year and at the same time supplying fish in good quantities. No villager will object to re-excavation of his tanks, if the major part of expense is borne by Government.

16. MR. J. N. MAITRA, Calcutta.

If we want to produce more food and fodder we must have a 'plan' approved by and supported by a popular Government aiming at improving the nation at large. There must be planning of central and provincial sections. Along with central and provincial plans, a plan for domestic food-planning must be popularized so that members of household, rich or poor, are fully convinced of the planned menu. Suitable educative propaganda must also be made in such a way that ready collaboration of the popular village workers are available for the desired result.

17. MR. NARENDRA M. BASU, Calcutta.

In planning food for the people of India under the present emergency conditions, it is necessary for us to remember two most important points about nutrition, viz. calorie requirement and protein requirement. The acute shortage of rice and wheat, two staple foods of India, leads us to think of a cheap and easily available substitute. In England attempts are being made to use grass for human consumption. It contains over 20% protein and very good mineral salts. Its great defect according to British scientists is its content of long cellulose fibres which might become massed in the alimentary canal and cause obstruction. But the speaker's personal experience with lawn mowings of that type of grass, known as *durba*, is different, since there was no gastro-intestinal trouble after partaking of food prepared with these fresh lawn-mowings.

Another substitute for rice and wheat is soya bean. It can be grown in both water-logged and dry places. It has been actually grown in different parts of Bengal, such as Tollygunge, Serampore, etc. Its high protein-content and fat-content are assets to people living mainly on rice, of which the protein-content is so low. A hot discussion raged about the biological value of its proteins amongst Indian scientists, but Steenbock and others have shown that the biological value of its proteins is nearly doubled if soya bean is subjected to heat (nearly 150°C. for 2½ minutes) The speaker strongly emphasized the necessity of cultivating this crop in India and popularizing its use amongst the poor of this country. Merely filling the stomach will not do. Unless 18% of our food is good protein, good growth will not take place. Rice contains between 6% to 7% protein. Soya bean would be a very good supplement to rice.

18. MR. D. MUKHERJEE, Calcutta.

Food growing can be immediately increased by giving a subsidy to the cultivators for reclamation of land and re-excavation of tanks and ponds for growing fish. Instead of waiting for long planning of agricultural improvement, the proper practical directions should be given to the cultivators and food-growers.

19. MR. POONA APPAJI RAO, Calcutta.

In the campaign of food and fodder, the problem of transport is important.

We should request the Government of India to give special facilities by way of granting concession of railway and bus fares, parcel duty, toll dues, road cess, etc. We should also request the opening of more roads in villages for movement of food products.

Resolution adopted at the close of the Discussion.

The following resolution, with a Memorandum, was unanimously adopted with a request to the Executive Committee of the Indian Science Congress Association to give it suitable publicity and to forward copies to the proper quarters.

The Indian Science Congress Association draws the attention of the Government and people of India to the seriousness of the food situation in the country, both for human beings and for farm animals, and in order to strengthen the food front *resolves* that 'a body of experts in agricultural and animal husbandry, nutrition, technology, geography, several branches of economic and political science, biology and physiology, transportation and price behaviour be formed at the centre and in the Provinces and States in India. The object of this body would be to study the food problem in its inter-related spheres on a regional basis, to pool the knowledge for purposes of planning and to co-ordinate activities for All-India and inter-provincial purposes. It will be necessary to secure the help of the inter-connected administrative departments of Agriculture, Communications, Drainage and Irrigation, Industries, and Public Health, where necessary. This body would also find out alternative sources and substitutes for essential foods whose supply had run short.'

Memorandum.

1. More land from the so-called culturable waste and some reappropriated from the area under non-food crops should be brought under cultivation of food crops. The amount of culturable waste and current fallow should be reduced to the minimum.

2. In order to achieve immediate results, locally produced manure, irrigation and drainage facilities should be given to the cultivators free or at a nominal cost wherever possible.

3. A suitable crop-planning scheme should be adopted for every Province before the next *kharif* season, so that both human food crops and, what is also important, fodder crops for working and milch cattle can be grown. A proper allotment of land must be made so that we get regional self-sufficiency in as many areas as possible.

4. Every incentive should be given to produce, preserve and bring into the market all kinds of animal products such as milk, meat, eggs and fish. An abundant fish supply could be assured to Provinces having extensive coastal and riverain areas which would meet the requirements of a protein food of high biological value. There is also a large scope for the growing of vegetables.

5. Special attempt should be made to increase the milk production of the country. If increased fodder supply is available, it is possible to increase the milk production in the country by 5–10% in a year which will meet the ordinary demands of *ghee* for the army without dislocating the civil needs.

6. It is essential in fact that there should be organized planning as regards production and conservation, transport and marketing, while there should be a minimum price guarantee to the producer by the help of subsidies if required.

7. Effective steps should be taken to prevent adulteration of foodstuffs.

8. Suitable educative work should be undertaken against hoarding, misuse and waste of food, and to propagate improved methods of cooking for the conservation of nutritive ingredients.

VIII. NEED FOR A PSYCHOLOGY IN PLACE OF PSYCHOLOGIES.

(*Section of Psychology and Educational Science.*)

Dr. S. C. Mitra, Calcutta, presided.

1. Dr. S. C. Mitra, Calcutta.

If there be room for divergence of opinions even in sciences which deal with phenomena directly perceived by many at a time, it is hardly to be wondered that differences will abound in a science, the materials of which certainly do not belong to the category of the tangibles and the conclusions of which consequently are only indirectly justifiable. The various points of view in the field of psychology are in conflict with one another to-day, but there is nothing to be ashamed of at that state of affairs.

An appreciation of the conditions under which a situation has inevitably come to pass, does not of course necessarily imply any assertion that the situation ought to be tolerated. If by reference to accepted standards of valuation, the continuance of the situation be considered undesirable, things should be then so re-arranged, and conditions should be so modified, that if not immediately, at least gradually, the situation may lose its significance and cease to operate as an influencing factor. I definitely believe that the present position of the science which we all in our own way are trying to serve, is a very grave one and unless efforts are directed towards discovering and organizing an unifying principle, the 'personality' of psychology may be totally disrupted in the near future. The consequence will be that it will cease altogether to exist as an independent science and will in course of time come to be regarded either as an adjunct to the study of statistics, or a particular method of interviewing candidates for jobs, or a special form of treatment for sexual aberrations. The crisis can be avoided if the psychologists turn their attention away for some time from the glamour of the brilliant successes that have been achieved as a result of the application of psychology in the different practical fields of life, and direct it towards consideration of fundamental questions, even though they be of theoretical interest only. We shall do well to examine anew the postulates and basic assumptions of our science. Of late, dazzled by the brilliance of initial success in our attempts to apply psychology, we have gone continually devising new tests and refining old techniques till we have brought about such an emergent situation that psychology is in danger of being lost in the wood of psychological tests. It is farthest from my intention to minimize in any way the services that have been rendered to the individuals and to the society by the application of these tests. My contention is that immediate or 'neck to neck' social service cannot and should not be regarded as the only possible goal of scientific investigations.

I would maintain that psychology and applied psychology should be kept apart and studied separately. In one sense, of course, there cannot be any difference between them, for applied psychology is nothing but psychology applied to particular classes of problems. But as has been pointed out by Titchener there is a difference of initial attitude between Science and Technology. 'The scientific man follows his method whithersoever it may take him. He seeks acquaintance with his subject-matter and he does not at all care about what he shall find, what shall be the content of his knowledge when acquaintance with is transformed into knowledge about. The technologist moves in another universe: he seeks the attainment of some determinate end which is his sole and obsessing care and he therefore takes no heed of anything that he cannot put to use as means towards that end.' Besides this difference in initial attitude and mainly as a result of this difference there arise actual differences in

the nature of the problems undertaken by the psychologists, on the one hand, and those who apply psychology on the other. As the nature of the problems differ, the methods would necessarily vary and thus we may gradually travel very far away from the course we adopted as our own. I would therefore suggest that whenever psychology is taught as a scientific subject, let there be two different departments, one concerned primarily with scientific investigations as such and the other with applications of psychology to the concrete problems of life. Some common ground must be covered by both because practice and theory cannot be forcibly divorced from each other. The applied psychology department will have varied problems to deal with. These would lead, as they have already done, to discovery of new methods and special techniques which however may neither be applied nor prove useful in the solution of problems investigated by the other department. My conclusion is that there is need for a psychology but not in place of psychologies but over and above them and bringing them into organic relation with one another.

2. Mr. P. S. Naidu, Allahabad.

Before we attempt a solution to the problem of unity, we should classify the existing schools of psychology. A three-fold classification of contemporary schools into Bio-static, Field-dynamic and Psycho-dynamic classes is valuable for our purpose. The first group comprises all the mechanistic schools which look for the explanation of behaviour in antecedent causes, the second comprises the Gestalt and the allied schools which deal with the present status of behaviour, and the third, the purposivistic schools. Our scheme for unity consists not in discarding any of the contemporary schools, nor in suppressing the individuality of any of them, but in keeping all of them and displaying them as successive stages or levels in a complete scheme of scientific explanation. Judged in this way the mechanistic or bio-static schools occupy the first stage of factual description and classification, the field-dynamic schools fall in the second or middle stage of preliminary analysis, and the psycho-dynamic schools occupy the highest stage of scientific explanation. No school of importance has been omitted from our scheme. All of them have been displayed as essential components of a hierarchical scheme of unity. Unity in psychological theory can be achieved, therefore, by taking the psycho-dynamic group as the crown and consummation of all other groups.

3. Mr. N. S. N. Sastry, Mysore.

Convenience of study may be responsible for different systems. But science demands that these should be limbs of an integral system. A system in which there may be a compromise of all the different systems has to be evolved, and such a system will probably be *extended hormism.*

4. Dr. I. Latif, Lahore.

There is only one psychology—the scientific psychology. The various schools within the field of psychology inasmuch as their data, procedure and results are controlled by scientific regulations, contribute towards building the superstructure of scientific psychology.

5. Mr. M. Z. Abdin, Madhubani.

Personalism borrows all that is of value in the different schools and adds to them to form an integral school of psychology. Evidence from introspection and observation shows the unity of living organism.

6. Mr. Raj Narain, Lucknow.

In order to replace psychologies by a psychology, the sources of conflict among the various schools are to be traced. These appear to lie in personal ambition, the prevalence of partisan spirit, the exclusive

emphasis on a single principle, the philosophical predilections, etc. A unified psychology can be obtained by guarding against these sources of conflict.

7. Mr. S. Jalota, Jullundhur.

There is necessity for electicism in modern psychology. Electicism recognizes that there is some truth in each systematic account or theory; it also does not overlook the fact that all theoretical viewpoints often come across several extremely difficult and some practically insoluble problems. But what often appears to be insoluble from the point of view of one theory may be easily solved from that of another.

8. Dr. R. Ghosh, Calcutta.

Scientific attempt at substituting psychologies by a psychology will become futile. Historical sanction behind the existence of the various psychology is not unwarranted. At every step of psychological understanding one finds within oneself certain difficulties which are not of intellectual nature but are of emotional constitution. Their root causes are embedded in the unconscious. Such emotional difficulties will not yield to intellectual discipline.

9. Mr. S. P. Ghosh, Calcutta.

The attempt to unify psychology will only end in giving rise to a new psychology in addition to the already existing ones. The need for replacing the psychologies by a psychology is not pressing.

IX. SHOULD THE EDUCATION OF GIRLS DIFFER FROM THAT OF BOYS?

(*Section of Psychology and Educational Science.*)

Mr. S. K. Bose, Calcutta, presided.

1. Dr. N. Mukherji, Calcutta.

The term education needs clarification. To remove confusion we should distinguish between (*a*) *academic education* and '*total*' *education*, as also between (*b*) *education* and *culture*.

It would be futile to look at education as an independent means for uplift of society, independent of other factors in life, specially socio-economic factors. Education is the shadow of political idealism prevalent in a country. At the same time, it is the existing political ideology which determines the status of men and women in any society.

Consequently, to the question, 'Should education of girls differ from that of boys' the answer would be, 'It depends on the nature and direction of the wind of politics blowing over the particular country at the particular period'. China, Germany and the U.S.S R. provide the most suitable instances in this respect. In the Imperialist Germany the answer was 'yes', under the Weimar constitution it was a mild 'no', while to-day it is an emphatic 'yes'. To the same question, India had replied 'yes' even during the tens of this century, an indefinite mixture of 'yes' and 'no' from the twenties to date, and now she is on the verge of making a definite decision.

If we do not close our eyes to the brilliant examples set by the people in China, Spain and the U.S.S.R., it is to be granted that women are as good as men in any important sphere of human activity. Looking at the problem with a more realistic vision one would rather ask, '*In what spheres* the education of girls should differ from that of boys?'

Treating the problem from psycho-biological point of view, it spreads up as follows: (1) as women are not capable of tasks requiring heavy

physical exertion, their education would differ from that of men in this respect (as in the choice of certain vocations), in the same way as some boys have to curb their intentions for a particular vocation due to physical incapabilities; (2) as the rate of mental and physical growth is not the same in boys and girls, curricula and syllabuses in academical grades would not remain same for both the sexes.

2. MISS P. DAS, Calcutta.

Some are of opinion that education of girls should differ from that of boys because of the danger of girls becoming 'mannish' and boys being effiminate. But do we not see this 'masculine protest' in women in the West particularly in assuming male attire and in engaging in male occupations, and unfortunately also amongst a few so-called 'modern' women in India? This is a case of deliberate suppression of the essential elements for the expression of their true selves. The underlying reason for it is both psychological and sociological. There may be a protest against the age-long domination of woman by man or the pathetic imitations may be the result of a feeling of inferiority! But whatever may be the cause for such behaviour, we cannot but look upon it as an 'experiment,' and one wonders how long outraged nature will suffer the experiment to continue!

Then again if education is to help a person to adjust himself to family and society, surely that implies relationships with both men and women. So that if girls and boys are educated together, in the sphere of personal relationship they will find a fuller, more conscious and more satisfying an existence. The school is a miniature society and surely both man and woman have their places therein!

Education, we are told, is to be both of the head and the hand. There are very few sorts of handwork which can be labelled as wholly masculine or feminine. Girls often show real skill in carpentry and boys at cooking or knitting. But nevertheless it is on the handwork side of the curriculum that the sexes usually tend to separate not by force but by choice. Housecraft may be systematically taught,—girls in laundry, cooking, housewifery and some other special training for older girls needing it, and boys in simple mechanics, carpentry, etc.

Psycho-analysts tell us that all human nature is characterized by what we might call a 'duality of sexes', so that there is part of woman in every man and *vice versa* and surely we see this statement is true to some extent without going far into the depth of psycho-analysis!

So this provides still another reason for advocating similar education for girls and boys.

What is really wanted, therefore, is not that education of boys and girls should be different but that the organization of schools be so elastic as to permit necessary adjustments and to make room for freedom in the choice of subjects and for variations in the methods of approach to the different subjects and their treatments.

But any educational problem is also essentially a sociological one. Ultimately, therefore, it is to be determined by the outlooks and ideals, the customs and traditions, the morals and sentiments of each country, e.g. in Soviet Russia we find boys and girls regarded as so many 'cogs' in the wheels of the State, so that the question of differentiation does not arise, with the result that 'there are no women in Russia' as an eminent person observed while giving his impressions of the country immediately on his return.

In India, the traditional conception of 'woman' is as 'the mistress of the house'. But now we find the social outlook growing wider and broader and the newly awakened political consciousness has brought into existence a movement for the emancipation of woman. Indian women are found working side by side with men (and sometimes even competing with men) in educational and social work, in law and in medicine, and even in industry and politics. But we need a word of caution here.

We must remember that our masses are still untouched, the social, political, and economic conditions being what they are, it will be unwise to force the pace of matters, to press for too radical a change, or to superimpose the pattern of a new idea or ideal on to a setting that is rather ancient, if not of a different nature !

3. Mr. Pars Ram, Lahore.

Differences in mental development and abilities between boys and girls do exist but they are minor ones. They are of minor importance in the intellectual abilities and outstanding and pronounced in the field of instinct and emotion. Difference between the best boy and the poorest boy in a particular mental ability is much greater than the difference between an average boy and an average girl.

There is very little native difference in the abilities of boys and girls. Culture and traditions, however, tend to exaggerate these differences. In certain culture groups women get poor food and no opportunities exist for them for intellectual and physical development. In those communities the conviction that women are unfit to take to engineering and the allied professions has gained currency. In culture groups where equality of sexes is accepted as an axiom, women have shown a remarkable capacity for the professions hitherto believed to be the exclusive monopoly of men. Women mathematicians of ancient India, efficient women rulers of all countries, thousands of women engaged in active war work in China, Russia and England give lie to the belief that women are inherently incapable of taking to certain professions.

It follows from the above that mere sex differences in abilities do not justify a separate system for boys and girls. In so far as the aim of education is to transmit to the educand the knowledge and wisdom acquired by the human race, this has to be the same for both the sexes. Truth is the same for both sexes and the process of transmitting it to the two sexes must be the same. Whether this is to be done in a high-walled purdah school or in open air mixed school is beside the point here.

Often a case is made for a special education for women on the ground that education must suit the talents and temperaments of the educand. This is a sound principle but it only suggests that pupils of superior ability should be taught in a special way just as those with inferior ability are to be taught in a special way. The classification is to be made on the deeper mental differences rather than on sex differences.

Much confused thinking prevails in regard to the aim of education at the secondary stage. The cry for a special education for women when analyzed is nothing more than a demand for a differentiated vocational education (at least education with a vocational bias) after the age of eleven. While general and liberal education for the two sexes has to be the same, social and vocational education has to differ in different social groups for the two sexes.

4. Dr. Rabi Ghosh, Calcutta.

That the educator is an architecht is a magnificent idea but is it not that the design of the architecture must be pleasing to the party at whose dictate the architect has undertaken the task ?

The social need and the duties which the parents impose on the teacher when their wards are sent to the school are very important to the educators.

It is neither fair nor possible to throw the whole of the population (included in it men and women) into states of anxiety by bringing together boys and girls for purposes of education.

At the nursery stage of education experiences verified the impression that a mixed education is an unmixed delight. If that be the case in the nursery schools, why should it differ in the junior schools if it not be that the educational authorities, unable and unwilling to solve those complications which a mixed education will bring about at the junior stage, refuse to solve the attendant difficulties and therefore advance

suitable justifications for preventing boys and girls from enjoying the unmixed delight of mixed education at the junior stage?

5. MR. J. K. SARKAR, Muzaffarpore.

Dual education and isolation lead to the under-education of women. Co-education and association make for their over-education. The ends of all the different forms of education are mainly formative and productive. The formative end is achieved by dual education while productive end is more or less served by co-education.

6. DR. (MISS) M. FALK, Calcutta.

Co-instruction is not advisable at earlier stages in consideration of quicker mental development of girls. In place of the sentimental explanation advanced in the case of professional disabilities as thrust on women, a historical and ethnological explanation may be proposed. The two basic structures of society—matriarchic and patriarchic—have probably a large say in the matter.

X. THE PROBLEM OF WORK AND REST IN PUBLIC INSTITUTIONS.

(*Section of Psychology and Educational Science.*)

MR. S. K. BOSE, Calcutta, presided.

1. MR. A. N. BASU, Calcutta.

Work and rest form a part of the rhythm of life. We cannot work for all time even if we so wish; and though at times we may so desire, we cannot for ever be resting, i.e. sit without doing something. Work and rest must be alternated, that is the law of life.

Psychologically speaking, the problem of work and rest is the problem of the well-known phenomenon of fatigue. This problem has been extensively studied by psychologists and a lot of experimental work has been done. It has been suggested that what is generally and popularly called mental fatigue is really physical in nature. Experimenters have also tried to formulate certain laws on the basis of their experiments. It has been suggested that rest is essentially a change in the occupation. It has also been found out that there is always an optimum period of rest which will vary with different occupations.

Now, all these generalizations have been based on laboratory experiments and they are also supported by experience. But while in western countries the problem has been and is being studied under actual conditions, i.e. in offices, factories and other types of institutions, I am not aware if something useful has been done in this direction in this country. The conditions in India differ very much from the conditions of work in western countries and so generalizations arrived at on western data may not be wholly applicable here. It is therefore necessary that Indian psychologists should also undertake this kind of work and should have for this all necessary facilities. In a poor country like ours we can ill afford to waste time or energy on unproductive work. To give an instance of the kind of work that may be undertaken, I suggest that a particular type of occupation be chosen and a close study of output of work done by workers engaged in that occupation in different centres be studied under standardized conditions. Such a study will furnish us with data which will allow us to find an effective solution of the problem of work and rest as far as that particular occupation is concerned. We can then with proper organization ensure that we shall get the maximum output with minimum of waste of human energy in that particular occupation.

The problem of work and rest is, from the point of view of the educationists, an important and urgent one. How shall we prepare our

time-table for work in our educational institutions in order that fatigue may be prevented and the optimum amount of work may be done? So far we have depended on empirical knowledge for doing this. It is necessary that scientifically planned experiments are undertaken in this country to provide us with sufficient data on which we can base our conclusions and formulate our procedure.

Planning our holidays and vacations also needs study. Some of us know to our cost how the holidays sometimes have a disturbing effect on our work and how instead of giving us rest succeed in doing just the reverse. Some occupations seem to be specially fortunate in the number of holidays they provide; while in others there appear to be so few holidays as to be detrimental not only to the workers but also the output of work. A closer touch between the psychologists, on the one hand, and trade and industry on the other, may perhaps provide us with effective solutions for these and similar problems of our national life.

Before concluding I would like to draw your attention to one characteristic feature of rest. The extent to which we succeed in introducing the element of joy in any particular kind of work, will be a measure of an automatic and constantly functioning source of rest. How this element of joy and pleasure works to that effect, how it brings into play the phenomenon of inhibition I leave you to discuss. There can hardly be any doubt that this is an important aspect of the problem. We cannot study the problem of work and rest without understanding clearly how a feeling of pleasure and joy relieves monotony and removes fatigue. Perhaps psychoanalysis may provide us with a satisfactory knowledge of this interesting aspect of a highly important problem.

2. Dr. Rabi Ghosh, Calcutta.

The problem of rest-pauses has been quite extensively studied in industrial establishments in Europe and America. In England since 1924, the Industrial Fatigue Research Board, later known as Industrial Health Research Board has been engaged in investigating the various aspects of this problem. The results of these investigations have been published by H.M. Stationery Office. In 1939, National Institute of Industrial Psychology published the investigations of Ramsay, Rawson and others into the problem of Rest-pauses and Refreshments in Industry.

In India this problem has not been studied either in industry or in schools. Although our schools indulge in allotting an arbitrarily arranged system of rest-pause, no investigation has yet been needed to find out suitable rest-pauses for different climates, social habits and geographical situations of the respective locality. The effect of suitable rest-pause is most keenly felt in industry.

In England, owing to influence of Dr. C. S. Myers, rest-pauses and their adjustment in industry occupied the attention of industrial psychologists. Finally the Government as well as the industrialists listened with care to their findings. The Factories Act of 1937 exercised great influence on the introduction of rest-pauses in industry. The employer welcomed this introduction because of its positive effects on the efficiency of the workers, the quality of output, and morale of the workers. The workers willingly submitted themselves to this planning because it removed their fatigue and monotony produced by their respective jobs. In 1924, 38%, in 1931, 53% and in 1938, 71·5% factories were employing the rest-pauses between their work. There are four types of rest-pauses prevalent in British factories: Simultaneous rest-pauses—during which all or the great majority of workers stop work at the same time; rota rest-pauses—which are taken in rotation, individuals or groups stopping work for specified periods at various times; official own time—rest-pauses officially sanctioned by the management but the time of stoppage is selected by the workers themselves; unofficial own time—rest-pauses not sanctioned by the management but which owing to tradition, the nature of the processes or indulgent supervision, are taken at the discretion of the workers.

In 1925 Wyatt and Fraser reported the objections of the employer and the employee: 'Irregularly recurring and unexpected stoppages usually tend to interfere with the rhythm and swing of work, and frequently occur when they are not wanted and least needed. They are often annoying interruptions to continued activity and have disturbing effects upon the attitude towards the tasks.'

The investigations of Ramsay and Rawson revealed that a rest-pause of 10 min. taken 2 hours after the beginning of a 4½-hour shift in the morning and that of a 4-hour shift in the afternoon has been the most satisfactory. Rest-pauses to have the most effective results must be regarded not in isolation but as a part of the general policy of the management. Rest-pauses are only one method of combating fatigue and boredom. In some cases instead of a complete cessation of work, slowing down of activity (accompanied possibly by a reduction of machine speed), change of work, provision of smaller or larger units of work or use of music may have equally beneficial results.

Dangers of fatigue must be reduced in every possible way. Before a specific method is introduced, every effort must be made to deal with those factors which may induce fatigue. Such factors are posture, bench layout, shop layout, machine design, tool design, heating, ventilation, lighting, production control, incentives to work, efficiency and supervision. The selection of the most suitable employee for the job may also be an important factor in reducing the possibility of fatigue.

In 1937 in England investigations revealed that there were 104 factories out of 970, which had introduced music either in conjunction with rest-pauses or in place of them. It was found that the greatest increase in output was obtained when music for a period of 75 minutes was played about the middle of the work-spell, but the most popular arrangement was provided by the introduction of music during alternate half hours throughout the work-spell. Different arrangements may be necessary in different organizations to suit the nature and conditions of work. Dance-music having foxtrot or quick tempo was preferred due to kinaesthetic sensation-rhythm enjoyed by the workers. About 75% of these factories which provided music at work noticed beneficial effects on efficiency, work becoming steadier and monotony of piece-work relieved. *Music at work*, though as old as the art itself, is still in its infancy as far as its adoption at factory is concerned.

In July-August, 1935 number of *Human Factor*, Louis Katan expressed hope of exploring the possibilities and value of unaccompanied singing for increasing the quantity and quality of work. But the increasing noise of production has been noticed as the disturbing factor for introducing singing to relieve the monotony and fatigue of work and to increase efficiency and the quality of work.

In schools, particularly where the formal education follows the rigid routine, frequent rest-pauses are needed not merely because of relieving fatigue but they are needed to let the children relax and enjoy freedom between two periods of a school-routine. Children do not willingly submit to routine-discipline at school, however much they may be told that the strict adherence to routine-work is needed for their own good. Children will always take the school-work grudgingly with a task-feeling and the teacher as a dictator at whose command they will have to sacrifice personal gratification and blissful freedom. If therefore an interim period, however small that may be in the measure of time, be granted after each period of work, the children will more willingly apply themselves to the discipline of rigid schooling during the routine period.

In nursery schools where children are allowed full freedom to develop their interests for knowledge in their own way, opportunities to follow their own trends; and where teachers do come down to the level of children instead of the latter being asked to reach the expected patterns of behaviour by the teachers, rest-pauses do not appear as problems demanding consideration and solution. A restless child is not tutored to become

restful. But attempts are made to give him necessary insight into his restlessness and thus enlightenment removes what appears as an obstacle in imparting education. A restful and applying child is offered ample scope for assimilation and application. There the child is afforded a home for happy living.

In formal schools, the children are forced to assume the required standard of studenthood. Such a demand on the child by the teacher and the school appears usually as severe and too-crucifying a test to the child. A small but sure relaxation after each period of fulfilling such a demand will be received and utilized by the child as a kindly gift coming from a benevolent father-substitute—the teacher. Therefore, it is more for psychological purposes that frequent rest-pauses are required after each period of school-work.

Here we enter upon the most interesting aspect of the problem of fatigue, namely fatigue brought about by the tensions in the mind. In those instances where the mind has become the seat of a conflict, manifest or latent, fatigue may quickly set in as manifestations of conversion symptoms. Like headache, fatigue and subsequent inability of good applications are to be understood from the standpoint of the unconscious mind. Who can deny that at times of mental strain, vast stores of psychic energy remain bound up and thus unavailable for productive labour and human creation? Anxiety, apprehension, etc., are yet other factors which diminish productive ability and increase 'fatiguability'. There are people who are more often in states of anxiety and apprehensiveness than not. In these people, I am afraid, rest-pauses will not be of much help.

3. Mr. Sarojendranath Roy, Calcutta.

Influence and effectiveness of rest-pause in industry are universally accepted. The different reactions of the workers as a result of unauthorized and authorized rest-pause point to the importance of the latter. Some study of the factors upon which the productive value of rest-pause depends has been made but there is urgent need for undertaking further research in this field, particularly in our country.

4. Mr. K. D. Kapur, Lucknow.

Problem of work and rest is to be considered only with reference to factories, offices, courts and educational institutions, where regulation of conditions of work is within the competence of government of the country. Conditions of work and rest in India have been irrational on account of imposition of British conventions born of a different climate and social economy. Alternation between work and rest should be rhythmic in the interest of the work and worker. This rhythm can be ensured by tuning both to our climatic environment and social economy. India is a tropical country and while British institutions are tuned to urban life, ours are to be tuned to rural life. In India hours of daily work should be shorter; hours near noon should be reserved for principal meal of the day and rest. These hours should not be less than three in summer and less than two in winter. Hours near morning and evening are best for work, worship or play. Shorter hours of daily work in warm climate should be made good by larger number of working days in the year. System of holidays in institutions related to rural life ought to be different from those related to urban life. Reference was invited to *Holidays and Timings* issue of the *Education* for detailed consideration of reform in educational institutions. The problem as a whole deserved primarily the immediate attention of psychologists and Public Health workers.

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